OCS Study
BOEM 2021-047

Description of Helicopter Operations and Utilization in the Gulf of Mexico

U.S. Department of the Interior
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Description of Helicopter Operations and Utilization in the Gulf of Mexico

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ABSTRACT

In this report we estimate the amount of helicopter activity needed to support oil and natural gas operations in Federal waters in the Gulf of Mexico. To do so, we utilize data from the U.S. Federal Aviation Administration's (FAA) novel Next Generation Air Transportation System (NextGen). We track individual helicopters across space and time. We match this flight data to offshore activity to provide insights into the helicopter operations used to support specific offshore activity. We provide spatial analysis (i.e., "heat maps") of distances flown and takeoffs and landings both in the Gulf of Mexico and onshore. Merging helicopter trip data with offshore oil and gas operation data obtained from the Bureau of Safety and Environmental Enforcement (BSEE) data center, we index helicopter operations to the different phases of offshore activity including exploration, development, production, and abandonment and decommissioning. Results suggest that, from 2015 to 2019, there were an estimated average 152.5 thousand helicopter trips taken per year to support offshore activity.

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ABBREVIATIONS AND ACRONYMS

10-K	U.S. Securities and Exchange Commission Form 10-K
ADS-B	Automatic Dependent Surveillance-Broadcast
API	American Petroleum Institute
bbl	barrel
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CGOR	Cumulative Gas Oil Ratio
DOI	U.S. Department of the Interior
EIA	U.S. Energy Information Administration
FAA	U.S. Federal Aviation Administration
GIS	Geographic Information System
HSAC	Helicopter Safety Advisory Conference
NextGen	Next Generation Air Transportation System
OCSLA	Outer Continental Shelf Lands Act
OCS	Outer Continental Shelf
SAR	Search and Rescue
SEC	U.S. Securities and Exchange Commission
WTI	West Texas Intermediate Oil

1. INTRODUCTION

Helicopter operations are crucial to supporting offshore oil and gas activity. Helicopters are typically used to transport personnel and light equipment from service vessels, drilling rigs, production platforms, and pipeline terminals. The goal of this analysis will be to estimate the amount of helicopter activities used to support specific offshore operations.

The Outer Continental Shelf Lands Act (OCSLA) established a policy for the management of mineral resources on the Outer Continental Shelf (OCS) and for the protection of marine and coastal environments. The Bureau of Ocean Energy Management (BOEM), within the U.S. Department of the Interior (DOI), is mandated by OCSLA to identify, monitor, and assess impacts of OCS activities on the human, marine, and coastal environments. In fulfillment of this mandate, BOEM forecasts exploration and development scenarios for offshore oil and gas infrastructure. These scenarios make assumptions about the amount of service vessels and helicopters used in forecasting oil and gas infrastructure. Results of this report will be utilized in the construction of BOEM's scenarios for future environmental impact assessments.

This report is made possible due to recent technological developments in tracking helicopter operations. Specifically, the U.S. Federal Aviation Administration (FAA) is currently in the process of transitioning into its "Next Generation Air Transportation System"—hereafter simply referred to as "NextGen." This will allow us to consider data on helicopter flights at an unprecedented level of detail. Data generated from the NextGen system used in this report includes information on over 200,000 helicopter trips traveling over 11 million miles in the year 2017.[1] Where not specified, all analysis in this report will utilize data from the 2017 calendar year due to data availability. We are able to track individual helicopters across space and time. We will match this flight data to offshore activity to provide insights into the helicopter operations needed to support this offshore activity. We will provide spatial analysis (i.e., "heat maps") of distances flown and takeoffs and landings. Consistent with prior analyses on service vessels supporting offshore activity (Kaiser and Narra 2014; Kaiser 2016), we will index helicopter operations to the different phases of offshore activity, including exploration, development, production, and abandonment and decommissioning. In sum, these estimates can be used by BOEM to forecast helicopter activity for future environmental impact assessments.

[1] This includes only trips that were identified as supporting offshore oil and gas operations. We estimate that approximately 131,000 of these trips specifically support operations in Federal waters.

2. BACKGROUND ON HELICOPTER CONSTRUCTION, SERVICE, AND LABOR MARKET

Before conducting our analysis, we first provide an overview of the helicopter industry servicing offshore operations in the Gulf Coast region. It is important to note that the U.S. Bureau of Labor Statistics (BLS), the Federal agency responsible for collecting, processing, analyzing, and disseminating labor market information in the United States, does not provide estimates on employment in either the helicopter manufacturing sector or the helicopter transportation sector. Since this report focuses on an even more specific helicopter sector, i.e., operations related to supporting offshore oil and gas operations, we compile information from other publicly available sources to provide perspective on the size of this industry.

Information in this chapter is sourced from company websites, 10-Ks filed with the U.S. Securities and Exchange Commission (SEC), data publicly available from the Helicopter Safety Advisory Conference (HSAC), and news articles.

2.1. Helicopter Service Providers

Three firms operate a majority of the offshore helicopter business in the Gulf of Mexico: PHI, Bristow, and ERA. According to conversations with industry, these three firms likely make up about two-thirds of the activity supporting offshore oil and gas operations. They have all made investments in onshore infrastructure in the region, including passenger terminals, hangars, and flight strips optimized for heavy helicopters.

2.1.1. PHI

Petroleum Helicopters International (PHI) is headquartered in Lafayette, Louisiana, and has maintained a strong presence in providing helicopter transportation services to major integrated and independent oil and gas production companies. PHI has serviced many customers through the years, including Shell Oil, BP America, ExxonMobil, ConocoPhillips, and ENI (SEC 2019f). Their principle facilities are located on property leased from the Lafayette Airport Commission at Lafayette Regional Airport; this property houses their main operational, executive, and administrative offices and the main repair and maintenance facility. They also own an operating facility in Boothville, Louisiana, with landing pads for 35 helicopters. They lease property for operational and maintenance facilities located in Louisiana and Texas that represent a large investment and are deemed important to their operations. These locations include Morgan City, Intracoastal City, Houma-Terrebonne Airport, and Fourchon in Louisiana and Galveston, Texas. Additionally, there are domestic offshore operations-related facilities located at Alexandria, Cameron, and Lake Charles, Louisiana.

On March 14, 2019, PHI Inc. filed voluntary petitions in the United States Bankruptcy Court for the Northern District of Texas seeking relief under Chapter 11 of Title 11 of the United States Bankruptcy Code (SEC 2019e). As of September 2019, PHI Inc. has emerged out of Chapter 11 protection and reduced their debt by $500 million (Daigle 2019).

2.1.2. Bristow

Bristow Helicopters Limited (hereafter simply Bristow) is a British civil helicopter operator originally based in Aberdeen, Scotland in 1955. Today, Bristow is an international corporation, with the U.S. based Bristow Group headquartered in Houston, Texas.

Bristow Group Inc. offers helicopter transportation, search, and rescue, and aircraft support services to government and civil organizations worldwide. There are five geographical areas of operation: Europe, Africa, Middle East, Asia, and Australia and The Americas. In May of 2019, Bristow entered Chapter 11 bankruptcy proceedings in the South District of Texas. News reports have cited debts of $1.885 billion against assets of $2.86 billion. Similar to PHI, Bristow continued normal operations during its bankruptcy (Huber 2019).

2.1.3. ERA

ERA was founded in Alaska in 1948 to assist Federal surveyors as the U.S. Government was preparing to map the uncharted territories in Alaska and was initially called "Economy Helicopters." Economy Helicopters expanded its service model to include petroleum support in the Kenai Peninsula. In 1958, Economy Helicopters merged with Rotor Aids to form ERA. In 2019, ERA provided helicopter services to customers around the world, including Brazil, Chile, Columbia, India, Spain, and Suriname.

In June 2020, Bristow and ERA completed a merger under the name Bristow Group, Inc. Since completing the merger, Bristow is closing two of its facilities in Galliano and New Iberia, Louisiana (Johnson 2020).

2.1.4. Financial Information

Table 1 shows relevant financial information on these three major firms: Bristow, ERA, and PHI. There are a few important items to consider when interpreting the information provided in Table 1.

First, each of these companies is involved in helicopter operations that are not associated with offshore oil and gas operations in the Gulf of Mexico. For instance, Bristow conducts search and rescue operations in the Gulf of Mexico, and PHI provides air medical transportation for hospitals and for emergency service agencies.[2]

Information on Bristow is reported for the U.S. individually and for Bristow Americas, which includes North and South America. Bristow does not provide a breakdown for oil and gas only. Information for ERA and PHI is broken down globally, within the U.S. and then globally oil and gas.

In June 2020, ERA and Bristow merged but at the time of this writing a joint 10-K has not yet been filed.

[2] Source: U.S. Securities and Exchange Commission. Form 10-K. Bristow, ERA and PHI company websites.

Table 1. Helicopter Service Provider Operating Revenues

Operating Revenues (millions)	2014	2015	2016	2017	2018	2019
Bristow						
Americas – All Activities	$358.7	$351.4	$290.3	$208.1	$225.4	$221.5
U.S. – All Activities	$225.7	$222.7	$158.9	$87.2	$103.0	$105.2
ERA						
Global – All Activities	$331.2	$281.8	$247.2	$231.3	$221.7	$226.1
U.S. – All Activities	$281.9	$222.5	$171.1	$152.2	$157.3	$149.5
Global – Oil & Gas	$232.7	$203.8	$202.8	$198.4	$200.5	$195.8
PHI						
Global – All Activities	$836.3	$804.2	$634.1	$579.5	$674.4	-
U.S. – All Activities	$747.0	$722.3	$579.3	$530.1	$516.7	-
Global – Oil & Gas	$516.9	$459.6	$324.1	$298.4	$380.2	-
Oil Price ($ per barrel)	$93.17	$48.66	$43.29	$50.80	$65.23	$56.99

Note: Source: (SEC 2019a, c and e; 2018a, b, and c; 2017a, b, and c; 2016a, b, and c; 2015a, b, and c; and 2014a, b, and c.) Oil price is annual West Texas Intermediate spot price as reported by U.S. Energy Information Administration (EIA).

Evaluation of Table 1 reveals a few observations. First, of these firms, PHI is the largest supporter of oil and gas helicopter operations globally, with $380 billion in revenues in 2018. This is almost double ERA's oil and gas revenues globally in the same year and larger than all activities in Bristow Americas. Second, looking at ERA and PHI, oil and gas revenues have dropped precipitously since 2014 when the oil price was above $90 per barrel. In 2018, ERA operating revenues from oil and gas were 86% of revenues in 2014, while PHI's revenues were just 73% of 2014 revenues. Perhaps more surprisingly, revenues have been down even in non-oil and gas revenues.

2.2. Helicopter Manufacturers

Helicopter manufacturing is a specialized industry with a small number of firms. There are four major manufacturers that produce helicopters that support offshore oil and gas operations: Leonardo, Bell Helicopters, Sikorsky[3], and Airbus.

According to a review of company 10-Ks and a discussion with industry, there is typically a substantial delay between when a helicopter is ordered from the manufacturer and delivered to the purchaser. This is especially the case for medium (10 to 12 passengers) and heavy aircraft (16 to 19 passengers). For instance, PHI notes that significant unplanned delays could delay the implementation of their business strategies or materially increase their cost of meeting commitments to their customers (SEC 2018c).

Table 2 shows the fleets of Bristow, PHI, and ERA by helicopter manufacturer and helicopter size based on each company's most recent 10-K. There are currently a total of 919 helicopters across the three companies, including all global aircrafts.

[3] A Lockheed Martin Company.

Table 2. Helicopter Fleets and Helicopter Size

Helicopter Type	Light	Medium	Heavy	Total
Leonardo (AugustaWestland)	34	79	18	131
Bell	99	14	0	113
Airbus	96	0	21	117
Sikorsky	0	75	110	185
Total	229	346	344	919

Source: Data collected from PHI, Bristow, and ERA's most recent 10-K filings (SEC 2019a, c, and e). Light, medium, and heavy aircraft generally hold 4-9, 10-12, and 16-19 passengers, respectively. Helicopters can be either owned or leased by the companies. Totals listed do not necessarily match the sum of individuals. Data as reported on 10-Ks.

2.2.1. Leonardo

Leonardo is a helicopter manufacturer headquartered in Italy. Their operations span the globe with a focus in four major markets located in Italy, the United Kingdom, United States, and Poland. They manufacture AgustaWestland helicopters, which are commonly used in supporting offshore operations. As of 2019, Leonardo has reported a slowdown in their civil sector's market, which is primarily attributed to the significant decline across the entire oil and gas sector. Furthermore, North America has seen a continued decline over the last five years in favor of Europe and Asia (Leonardo 2020). The entire Leonardo Helicopters product portfolio is delivered from their Philadelphia facility. Leonardo also has a support center for the Gulf of Mexico located near Lafayette, Louisiana. This facility provides FAA and EASA certified blade repair, spare parts, and technical support.[4] As shown in Table 2, there are currently 131 Leonardo AgustaWestland helicopters in operation between PHI, Bristow, and ERA.

2.2.2. Bell Helicopters

Bell is a supplier of commercially certified helicopters that support corporate, foreign governments, offshore petroleum exploration and development, utility, charter, police, fire, rescue, and emergency medical helicopter operators. Bell produces light single- and twin-engine helicopters and medium twin-engine helicopters that are used for commercial operations (SEC 2019f). Approximately half of PHI's and Bristow's light aircraft fleet are made up of Bell single engine helicopters (SEC 2019f). In August 2020, Bell Textron Inc. unveiled a new 140,000-square-foot Manufacturing Technology Center (MTC) in Fort Worth, Texas. According to Textron's website, Bell operates seven manufacturing facilities near the Gulf of Mexico: two in Broussard, Louisiana; four in Fort Worth, Texas; and one located in Ozark, Alabama. As shown in Table 2, there are currently 113 Bell helicopters in operation between these three companies; 99 of these are light aircraft with the remaining 14 being medium.

2.2.3. Airbus

According to the company website, Airbus is the largest aeronautics and space company in Europe. It manufactures commercial helicopters that perform offshore oil and gas airlift duties, including servicing existing platforms, search and rescue, and pipeline surveillance. Its helicopters are deployed in the North Sea, Western Australia, India, the Gulf of Mexico, South America, Asia, Russia, the CIS, and Western Africa. The U.S. affiliate, Airbus Helicopters Inc., has more than 70% market share in North America and more than 2,600 aircraft in service in the region.[5] Its main facilities are located in Grand Prairie, Texas and it operates a production line in Columbus, Mississippi. Also, it provides world-class training, aftermarket support, and technical assistance throughout the region. As shown in Table 2, there are

[4] Source: Leonardo company website.
[5] Source: Airbus website. Incldues all market segements, not just oil and gas.

currently 117 Airbus helicopters in operation between these three companies; 96 of these are light aircraft with the remaining 21 being heavy.

2.2.4. Sikorsky

Sikorsky operates under the Rotary and Mission System business area of Lockheed Martin and supplies commercial aircraft for offshore operations in the Gulf of Mexico. As of December 31, 2018, Sikorsky's S-92A helicopter comprises all of PHI and half of Bristow's heavy aircraft fleet (SEC 2019d). As shown in Table 2, there are currently 185 Sikorsky helicopters in operation between these three companies, none of which are light. Sikorsky's Customer Care Center is based in Trubull, Connecticut.

2.3. Labor Requirements

Table 3 shows employment information from the three major helicopter companies supporting offshore activity. In 2018, these three companies employed around 1,900 people in total. For perspective, the U.S. oil and gas extraction and services sectors in the United States alone employed approximately 410 thousand workers in 2018, with approximately 266 thousand of these works in Texas and Louisiana.[6][7] Thus, while helicopter operations are absolutely necessary to support offshore oil and gas operations, the aggregate employment from this sector is relatively small.

Table 3. Helicopter Service Provider Employment

	2014	2015	2016	2017	2018	2019
Pilots						
Bristow (Americas)	200	190	150	130	130	-
ERA	240	270	226	213	181	205
PHI	891	770	618	697	595	-
Total Pilots	**1,331**	**1,230**	994	**1,040**	**906**	**-**
Mechanics/Maintenance						
Bristow (Americas)	390	230	200	190	180	-
ERA	231	262	225	204	190	219
PHI	905	845	776	738	627	-
Total Mechanics/Maintenance	**1,526**	**1,337**	**1,201**	**1,132**	**997**	**-**
Total Employment	**2,857**	**2,567**	**2,195**	**2,172**	**1,903**	
Oil Price ($ per barrel)	$93.17	$48.66	$43.29	$50.80	$65.23	$56.99

Source: (SEC 2019a, c and e; 2018a, b, and c; 2017a, b, and c; 2016a, b, and c; 2015a, b, and c; and 2014a, b, and c). Light, medium, and heavy aircraft generally hold 4-9, 10-12, and 16-19 passengers, respectively. Helicopters can be either owned or leased by the companies.

2.3.1. Fleet Size and Composition

Helicopters are classified as small, medium, and large; each serves a different transportation need of the offshore energy industry. Global demand for medium and large helicopters is heavily influenced by development and production activity levels in deepwater locations, as the medium and large aircraft are better suited for traveling to these deepwater locations. Generally, operations with shorter routes utilize small helicopters (SEC 2019a).

In recent years, service providers have increased purchases of larger aircraft intended to service deepwater activities. The margins earned on these aircraft are generally higher than those from smaller

[6] U.S. Bureau of Labor Statistics. 2018. Current employment statistics survey (national). All employees. Oil and gas extraction (NAICS 211) and support activities for oil and gas operations (NAICS 213112).
[7] At the time of this writing, Texas and Louisiana employment had dropped to below 200,000 workers due to COVID-19 and its impacts on energy demand (Dismukes and Upton 2020).

aircraft. Increases in deepwater offshore activity are usually followed with increases in demand for medium and heavy aircraft, which creates a positive impact on revenue and earnings for helicopter service providers (SEC 2019f).

As shown in Table 4, there has been a steady decline in total fleet sizes from 2014 to 2018. The most notable changes come from single engine and light twin helicopters. Single engine helicopters dropped from 271 in 2014 to 176 by 2018, while light twin dropped from 52 in 2014 to 25 by 2018.

Table 4. HSAC Fleet Size & Composition

Helicopter Type	2014	2015	2016	2017	2018
Single Engine	271	179	188	182	176
Light Twin	52	37	39	29	25
Medium Twin	96	80	69	80	97
Heavy Twin	46	50	48	43	38
Total Fleet	415	346	344	329	336

Source: 2018 Helicopter Safety Advisory Conference. As reported by HSAC. Totals are not necessecarily sum of helicopter types. Data as reported by HSAC.

2.4. COVID-19

The decline in demand for oil and gas during the pandemic has negatively impacted offshore operations and therefore the demand for helicopter service providers. The effect of this unexpected event is not limited to the oil and gas segments and has caused challenges for other segments of helicopter transportation due to the implementation of significant travel restrictions (SEC 2019b). In prior downturns in oil and gas activity, these providers have leaned on their other segments, but reduced travel broadly associated with the pandemic has caused a strain on the companies as a whole. This report was prepared during the COVID-19 pandemic and, therefore, any effects are beyond the scope of this analysis.

3. DATA

We utilize four primary data sources for this analysis. Most notably, we utilize the 2017 FAA NextGen helicopter flight data—hereafter referred to as "NextGen" (Chapter 3.1). Onshore spatial boundaries are obtained from the U.S. Census Bureau (Chapter 3.2). Data on offshore activity is from the Bureau of Safety and Environmental Enforcement's (BSEE) Data Center (Chapter 3.3). Finally, we utilize publicly available data from the Helicopter Safety Advisory Conference (HSAC), an industry association whose stated mission is to identify critical issues that affect safety in the Gulf of Mexico with regards to helicopter operations supporting offshore oil and gas activity (Chapter 3.4).

In this section, we provide a broad overview of helicopter trip determination using FAA NextGen position log data. A schematic of the data cleaning process along with a detailed description of the trip estimation steps is provided in Figure A.1.

3.1. FAA NextGen

3.1.1. Data Construction

The U.S. Federal Aviation Administration (FAA) has significantly upgraded flight technologies over the past several years. Namely, the Next Generation Air Transportation System (NextGen) is led by the FAA with the goal of modernizing America's air transportation system to make flying safer, more efficient, and more predictable (FAA 2020a). With NextGen, the FAA has implemented satellite-enabled navigation that is more precise than the (historically used) traditional ground-based systems. More specifically, NextGen is based on Automatic Dependent Surveillance-Broadcast (ADS-B). ADS-B Out[8] broadcasts an aircraft's Wide Area Augmentation System (WAAS) Global Positioning System (GPS) location and has been required since January 2, 2020, for all flights in specified airspace (AOPA 2020).[9]

At its core, the 2017 NextGen data contains spatial and temporal information about individual helicopter flights. Thus, at a given time, data are provided on the location and altitude of the aircraft. Most flight positions are updated every 5 seconds.[10] In total, the uncompressed data are over 165 gigabytes with over 440 million rows, and 1.5 million unique tracks were analyzed for the year 2017. Data were provided within the red bounding rectangle illustrated in Figure 1.

More information on identification of boundaries between land, State waters, and Federal waters will be discussed in Chapter 3.2.2. Federal waters extend 200 nautical miles offshore, with these boundaries shown in Figure 1. Any flight tracks outside of Federal offshore areas are also labeled out of study area, and therefore removed from the sample. As shown in Chapter 4.1, this makes up about one half of 1 percent of the sample.

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[8] ADS-B Out broadcasts the aircraft's location. In contrast, ADS-B In, which is not mandated, offers additional awareness benefits to operators in the aircraft in real time. For instance, ADS-B In allows pilots to use enhanced applications such as In-Trail Procedures and Interval Management (FAA 2020b). We are told that these features are more geared towards commercial airline pilots, less so offshore helicopter operations.

[9] It is important to note that not all aircraft are required to install ADS-B technology. Aircraft flying in Classes A, B, and C airspace, and other technical criteria are required.

[10] Some flights are updated as frequently as every 1 second, while others have large periods of missing data throughout the flight.

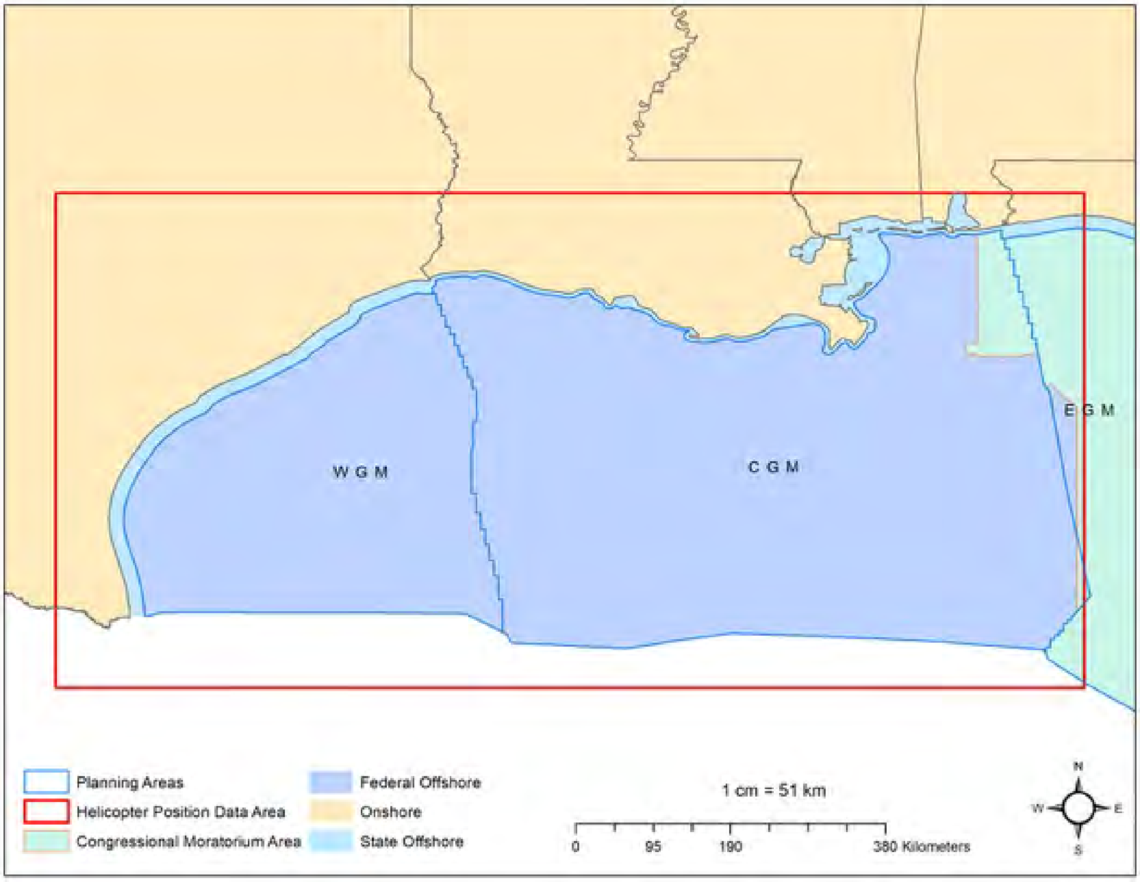

Figure 1. Illustration of the Study Area.
Source: Provided by BOEM.

The original position log data are imported into statistical software. Helicopter tracks are identified based on position sequence of an aircraft and start and end times. Position coordinates are then converted into point features in Geographic Information System (GIS) Mapping Software to allow for spatial interpolation of locations to create track polylines. Once track polylines were generated, several steps were taken to identify flights plausibly supporting offshore operations.

First, if the track originates or ends in a location that is not defined in the study area, data associated with the track are removed. We identify Federal offshore lease blocks, State waters, and census block groups in the States of Texas, Louisiana, Mississippi, Alabama, and Florida that also intersect (i.e., overlay) the helicopter position data coverage area (Figure 1). Note that a helicopter that originates within the study area but that flies directly north to an onshore location will be identified as its destination being onshore, as we are unable to identify (without further assumptions) whether the flight ended near the border or whether it continued further. Similarly, if a flight originates north of the study area, it will be identified as its origin being onshore. This classification does not impact our ability to identify trips plausibly supporting offshore activity and we therefore do not include additional decision rules attempting to differentiate helicopters that enter or exit in this way.

Second, we identify tracks that had either a takeoff or landing in Federal offshore or State waters using the start and end time and position coordinates. If the track does not start or end in a Federal offshore or State waters location, we determine if it is an onshore-to-onshore track that has an offshore stop based on the time difference between consecutive position coordinates, altitude, and distance traveled between time logs. We reassign the start and end time of each of these trips based on the time stamps of the corresponding offshore stops. If there are no offshore landings, these data are identified as an onshore to onshore track. As will be shown in Chapter 4.1, onshore-to-onshore tracks make up over 85 percent of the trips.

Third, after removing onshore-to-onshore trips and trips that originate or terminate outside of Federal waters, a residual 13 percent (200,242 trips) were assumed to support offshore oil and gas operations (see Table 6). We then identify whether each track segment is onshore-to-onshore, onshore-to-offshore, or offshore-to-onshore based on the start (origin) and end (destination) coordinates.

After individual track polylines are identified and cleaned, next we aggregate takeoffs and landings for each geographic area by 1-hour intervals. The result is a panel of geographic identifiers by 8,760 hours in the year. Hereafter, we will refer to a helicopter “trip” as

$$Trip = \frac{takeoffs + landings}{2}$$

In Appendix A, we present several examples of flights that, in the initial data (before the data processing shown in Figure A.1 is implemented), are denoted as onshore-to-onshore trips despite flying over an offshore area. That is trips that both originate and terminate in an onshore area but have flight paths that cross into an offshore area. These examples highlight multiple situations present in the data and discuss whether each observation would be included in the final dataset after linear interpolation.

3.1.2. Notable Data Uncertainties

There are a few notable data issues that are important to consider before proceeding.

First, and as mentioned briefly in Chapter 3.1, helicopters were not required to have ADS-B Out systems installed until January 2, 2020. The FAA NextGen data analyzed in this report is for 2017. We spoke with several helicopter operators, and these companies began installing ADS-B Out in 2017, while the majority of installations were conducted in 2018 and 2019. Thus, simply due to the year of data, coverage will not be universal. A future study analyzing data in 2020 and beyond could provide for significantly improved coverage.

Second, based on discussions with industry, helicopter ADS-B Out systems likely lose connection with transceivers as they travel below approximately 1,500-foot altitude depending upon their distance to a transceiver offshore. When they lose connection, they will no longer be included in the data. Thus, the first and last data point for an individual flight is likely not at the exact beginning and end of the flight in many instances. For this reason, additional analysis (see Chapter 5.1) will be conducted to determine the closest offshore activity when a helicopter’s track exits the data.

Each year, HSAC publishes its Gulf of Mexico Offshore Helicopter Operations and Safety Review. This report includes data on hours flown, number of flights, passengers carried, fleet size and accidents. In 2017, there were 492,000 flights and 189,000 hours flown. These data are based on the response from 10 helicopter operators. While the HSAC data do not cover 100% of helicopter trips, especially of smaller operators, we are told by conversations with industry that it likely covers the vast majority.

While these will create limitations for our study, additional analysis will be conducted to index helicopter activity to offshore activities when it falls out of the data and to scale the observed data up to represent the industry as a whole. This analysis will be presented in Chapter 5.

3.2. Spatial Boundaries

In this chapter, we discuss the spatial boundaries that will be used in subsequent analysis. Broadly speaking, we will identify onshore areas using census block groups, Federal offshore areas using BOEM lease blocks, and State waters as the residual between the two.

3.2.1. Census Block Groups

For onshore geographic locations, we utilize Census block groups designated and used by the U.S. Census Bureau (Census 2019). These block groups are agglomerations of Census blocks (the smallest level of spatial aggregation). Block groups can be aggregated into Census tracts, which are a larger geographic size.

We chose to use Census block groups as the onshore unit of analysis, as these units are closest in size compared to offshore lease blocks. For perspective, the average offshore lease block is 23 square kilometers, compared to the average Census block group in this analysis, which is 34 square kilometers. In comparison, counties/parishes and census tracts are much larger in land area while census blocks are far smaller (averaging less than 1 square kilometer). Approximately 1,200 census blocks across five states were identified to have helicopter activity supporting offshore activity.

3.2.2. Offshore Areas

GIS shapefiles of offshore lease block grids and boundaries in the Gulf of Mexico were obtained from BOEM (BOEM 2020a). About 90 percent of lease blocks are within the typical range of between 5,000 and 5,760 acres, which is 3 miles by 3 miles (i.e., ~23.3 square kilometers). Some lease blocks are smaller due to their intersection with State waters or at the intersection of Gulf of Mexico protraction areas defined by BOEM. We modified the shapefiles to properly differentiate between (1) onshore areas, (2) State waters, and (3) Federal water. Figure A.5 illustrates a portion of these three spatial unit boundaries along the coasts of Louisiana and Texas.

Because portions of some OCS lease blocks cross into State waters, we used the clipped lease block shapefile layer (BOEM 2020b) as provided by BOEM at the Federal-State boundary (BOEM 2020c). These clippings are illustrated in Figure A.6, Figure A.7, and Figure A.8.

Further, spatial data on onshore census block groups differ in their definitions across states. The original census block group layer covers the entirety of State waters for states with offshore boundaries that are 3 nautical miles from the shoreline (Louisiana, Alabama, and Mississippi) but only a portion of State waters for states with a 9-nautical mile offshore boundary (Texas and Florida). Therefore, we next clip the census block groups shapefiles at the shoreline and include all area between the shoreline and Federal-State boundary as State waters. An example of this is shown for Texas and Louisiana in Figure A.6 and Figure A.7, respectively.

We then dissect the resulting State waters into further areas. To do this, we consider Census block groups that are designated as water bodies by the U.S. Census Bureau. These water body boundaries, which correspond with State waters, are extended to the Federal-State boundary. The result is 32 State water areas across the five states.

3.3. Offshore Activity

In Chapters 3.1 and 3.2, we discussed the construction of the FAA NextGen helicopter data and spatial boundaries for onshore areas, State waters, and Federal areas. The next step is to identify offshore activity and match this activity to the appropriate offshore lease blocks. We consider nine categories of offshore activity: (1) exploratory well installation; (2) development well installation; (3) caisson installations and removals; (4) platform installations and removals; (5) flowline/trunkline installations and removals; (6) subsea completions; (7) producing gas structures; (8) producing oil structures; (9) auxiliary structures; and (10) well plug and abandonment. We further consider select activities by water depth. We categorize each activity as appropriate by water depth, noting that some activities are inherently constrained to deep or shallow water. While more granular water depth bins will be considered later in the report, we will generally refer to shallow water as less than 800 meters and deep water as greater than 800 meters consistent with BOEM precedent.

All offshore activity data were collected from BSEE's data center, with more detailed descriptions of each activity type discussed below. We provide a basic overview of each of these activity types, with descriptions based on sources such as Hyne (2012), Kaiser and Pulsipher (2007), and Mather (2000) in addition to the author's general research and discussions with helicopter and offshore oil and gas companies. Information on the occurrence of these activities over the 2017 calendar year (the year of helicopter data available) and over a longer time period from 2010 to 2019 (arbitrarily chosen to provide historical context) are shown in Table 5.

Table 5: Offshore Activity in the Gulf of Mexico

Activity Type	2017			2010-2019		
	<800-m Water Depth	≥800-m Water Depth	All Activity	<800-m Water Depth	≥800-m Water Depth	All Activity
Drill exploratory well	9	72	81	232	695	927
Drill development well	53	17	70	1,201	316	1,517
Install caisson	-	-	-	33	-	33
Remove caisson	33	-	33	646	-	646
Install platform	2	-	2	67	-	67
Remove platform	76	-	76	1,232	0	1,232
Install floating structure	-	1	1	-	13	13
Remove floating structure	-	-	-	-	3	3
Install gathering/flowlines (thousands of feet)	297	29	326	2,867	481	3,350
Install transportation/trunklines (thousands of feet)	136	-	149	4,877	18	5,178
Install subsea completion	4	25	29	21	274	295
Producing gas structure	227	-	227	439	-	439
Producing gas structure/manned	67	1	68	77	2	79
Producing oil structure	377	-	377	438	-	438
Producing oil structure/manned	266	37	303	266	36	302
Auxiliary platform	470	124	594	517	102	619
Idle structure	759	2	761	937	1	938
Plug and abandon well	377	45	422	5,829	406	6,235
Plug and abandon subsea completion	12	5	17	113	130	243

Note: For producing, auxiliary and idle structures, the average number of structures over the 2010-2019 time period are reported. Not all items will sum due to missing water depth information for some activities.

3.3.1. Exploratory Wells

When an oil and gas exploration and production (E&P) company enters a new area, it will first drill an exploratory well with the goal of locating new oil and gas reserves. Data on specific exploratory wells drilled are obtained from the BSEE data center's borehole database (BSEE 2020a).[11] The specific date and location of each exploratory well are utilized in subsequent analysis. As shown in Table 5, there were a total of 81 exploratory wells drilled in 2017. Of these, 9 were drilled in shallow water and 72 in deep water. From 2010 to 2019, there were 927 exploratory wells drilled.

3.3.2. Development Wells

In contrast to an exploratory well, development wells are drilled in the known extent of the field where reserves have already been identified with prior well(s). Data on specific development wells drilled are also obtained from the BSEE data center's borehole database (BSEE 2020a).[12] The specific date and location of each development well are also utilized in subsequent analysis. As shown in Table 5, there were a total of 70 development wells drilled in 2017. Of these, 53 were drilled in shallow water and 17 in deep water. From 2010 to 2019, 1,517 development wells were drilled.

3.3.3. Caisson Installation and Removal

Caissons are perhaps the simplest of structures offshore existing in water depths up to about 200 feet. Broadly speaking, a caisson is a large watertight structure for which water is kept out by air pressure. In this context, a caisson is a cylindrical or tapered tube enclosing a well conductor and is the minimum structure for offshore development of a well. There have been no caissons installed in the Gulf of Mexico since 2015. Since 2010 there were a total of 33 caissons installed, all of which were in water depths below 60 meters. As shown in Table 5, there were a total of 33 caissons removed in 2017.

Caisson installations and removals were obtained from the BSEE data center's structures database (BSEE 2020b).[13] The exact date of installation and removal are available for each structure.

3.3.4. Platform Installation and Removal

Two categories of platforms are grouped together for the purposes of this analysis, namely, well protectors and fixed platforms.[14]

Well protectors, also called well jackets, are an open lattice truss template consisting of a welded frame of tubular members extending from the mudline to above the water surface. Most well protectors in the Gulf of Mexico are three- or four-piled structures with minimum decks and production facilities. They are typically located in water depths less than 300 feet.

Fixed platforms are larger self-contained structures that include facilities for drilling, production, and combined operations. Fixed platforms are larger than caissons or well protectors and, in some instances, are manned 24 hours/day with sleeping quarters.

Well protector and fixed platform installations and removals were obtained from the BSEE data center's structures database. The exact date of installation and removal are available for each structure. In 2017, 2 platforms were installed and 76 were removed. By design, all of these installations and removals were

[11] Specifically, all boreholes with type code "E."
[12] Specifically, all boreholes with type code "D."
[13] Structure type code "CAIS."
[14] Structure type codes "WP" and "FIXED."

in shallow water. From 2010 to 2019, 67 platforms were installed with 1,232 removals. Thus, the number of platforms has declined.

3.3.5. Floating Structure Installation and Removal

Unlike caissons, well protectors, and fixed platforms that are physically affixed to the seafloor, floating structures are anchored using mooring lines. Floating structures are only installed in deep water, usually at water depths greater than 1,500 feet.

Floating structure installations and removals were obtained from the BSEE data center's structures database (BSEE 2020b).[15] The exact date of installation and removal are available for each structure. In 2017, one floating structure was installed, and none were removed. For this reason, our ability to estimate the helicopter trips needed to install and remove floating structures is limited. From 2010 to 2019, there were 13 floating structures installed and only 3 removed.

3.3.6. Flowline/Trunkline Installation

Once hydrocarbons come up from the wellhead, they must be processed and transported to markets onshore. A flowline is simply a pipe that is attached to the wellhead and brings the oil and natural gas to separation, treatment, or storage. Groups of flowlines are called gathering systems. An axial, or trunkline, gathering system has flowlines emptying into several wellheads that flow into a larger trunkline.

Flowline and trunkline installations and removals were obtained from the BSEE data center's pipelines master database (BSEE 2020c). The exact date of construction is available for each segment of pipe. A typical segment varies from feet to tens of miles. The specific lease block that is assigned to a pipe segment is based on the origin location of the segment. In 2017, approximately 326,000 feet of flowlines were installed, with 297,000 feet of this installed in shallow water.

We are told that typically pipelines are laid by pipelay vessels, and so our hypothesis is that significant helicopter operations are unlikely to be needed to support this activity. Nonetheless, we will present empirical tests.

3.3.7. Subsea Completion Installation

In Chapters 3.3.1 and 3.3.2, the drilling of exploratory and development wells was discussed. But once a well is drilled, it will not begin producing commercial quantities of hydrocarbons until the well is completed. This completion process typically includes the installation of a "Christmas tree," which is an assembly of valves, casing spools, and fittings used to regulate the flow of hydrocarbons out of the well.

A subsea completion is a subsea platform that typically consists of a Christmas tree with flowlines tied back to shore or an accompanying platform. Subsea structures at water depths greater than 1,000 feet are obtained from the BSEE data center's permanent deepwater structure database (BSEE 2020d), while the ones in water depths less than 1,000 feet are identified using the well name prefix ("SS') from the borehole database (BSEE 2020a). In 2017 there were a total of 29 subsea completions. From 2010 to 2019, 295 subsea completions were installed. The spud date of these wells is used to determine the number of subsea wells installed at the lease block level. These data are available at the daily level.

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[15] Structure type codes "SEMI," "SPAR," "TLP," "MTLP," "CT," "MOPU," and "FPSO."

3.3.8. Producing Structures

In Chapters 3.3.3, 3.3.4, and 3.3.5, we discussed the installation of different types of offshore structures including caissons, fixed platforms, well protectors, and floating structures. But once structures have been installed, they are supported by helicopter operations. Thus, we will also consider how many helicopter trips are associated with existing structures once in operation.

Producing structures are classified along two dimensions. First, structures are classified as either an oil or gas structure by obtaining the well level production data associated with each producing structure.[16] The well level production is aggregated at the structure level using the structure-well association data from the borehole dataset. The total oil and gas produced by a structure during 2017 and in turn the cumulative gas oil ratios (CGOR) are used to identify the type of producing structures. Cumulative gas oil ratio is defined as the ratio of cumulative gas production measured in cubic feet (cf) to total oil production measured in barrels (bbl). A structure with CGOR greater than 10,000 cf/bbl for the year 2017 is classified as a producing gas structure while a structure with CGOR less than 10,000 cf/bbl is classified as a producing oil structure. Since production is reported at the monthly level, all producing structure counts are also tabulated at the monthly level by individual lease blocks. Second, structures are classified as manned or unmanned structures. Manned structures have facilities for people to live 24 hours on the structure.[17]

3.3.9. Auxiliary Structures

Auxiliary structures are not associated with a specific well and are therefore not considered producing structures. For instance, an auxiliary structure might receive hydrocarbons from multiple production platforms and then pump further to shore. For perspective in 2017, there were a combined 975 producing structures and 594 auxiliary structures. Idle structures are those that previously were producing but are not producing at the time of observation. In 2017, there were a combined 961 idle structures, almost all in shallow water.

Auxiliary[18] and idle structures were determined using the BSEE data center's structures (BSEE 2020b) and Oil and Gas Operations Reports - Part A (OGOR-A) databases (BSEE 2020e).

3.3.10. Plug and Abandon Wells

Federal regulations require that all oil and gas wells be permanently plugged and abandoned (P&Aed) within 1 year after the lease terminates. Typically, termination occurs when production stops. In some instances, operators may plug and abandon non-producing wells on a productive lease early if it makes economic sense.

Well plug and abandonment were obtained from the BSEE data center's borehole database. The exact date and location of each P&A are available. Plug and abandoned subsea completions are also included in this category. In 2017, 422 wells were P&Aed. From 2010 to 2019, 6,235 wells were P&Aed.

3.4. Helicopter Safety Advisory Conference

The Helicopter Safety Advisory Conference (HSAC) was formed in 1978 to provide a forum for individuals, companies, and government agencies to exchange ideas, mutual problems, and solutions

[16] A well is identified using the American Petroleum Institute (API) well number.
[17] Manned structures are identified using the "Manned 24 Hr Flag" provided in the Platform Masters database, which indicates whether a platform has personnel onboard 24 hours per day.
[18] The list of corresponding structure types for these auxiliary structures includes "CAIS", "WP" and "FIXED" codes.

related to the safe operation of rotary-winged aircraft (i.e., helicopters). The group's focus is on air travel to support offshore oil industry and aerial surveillance of pipelines.

Each year, HSAC publishes its Gulf of Mexico Offshore Helicopter Operations and Safety Review. This report includes data on hours flown, number of flights, passengers carried, fleet size and accidents. In 2017, there were 492,000 flights and 189,000 hours flown. These data are based on the response from 10 helicopter operators. While the HSAC data do not cover 100% of helicopter trips, especially of smaller operators, we are told by conversations with industry that it likely covers the vast majority.

4. SUMMARY STATISTICS AND DESCRIPTIVE ANALYSIS

In this chapter, we provide summary statistics on helicopter operations data and show how these activities vary across hours of the day, days of the week, and months of the year.

4.1. FAA NEXTGEN SUMMARY STATISTICS

Table 6 provides summary statistics for trips, distances, and flight time by origin and destination. Panel A includes all helicopter trips that are candidates for supporting offshore oil and gas operations based on results of data processing discussed in Chapter 3.1. These trips are classified into three trip types: (1) onshore-to-offshore, (2) offshore-to-offshore, or (3) offshore-to-onshore. Panel B presents summary statistics on all helicopter trips that were removed from the analysis, as they are unlikely to support offshore oil and gas operations.

Table 6. Summary Statistics by Location of Origin and Destination

Trip Type	Trips	Percent of Total Trips (%)	Total Distance (km)	Average Distance Per Trip (km)	Total Time (hours)	Average Flight Time (minutes)
Panel A: Candidates for Supporting Offshore Oil and Gas Operations						
On-to-Off	77,326	5.02	8,243,670	106.6	75,412	58.5
Off-to-Off	69,788	4.53	2,026,463	29.0	14,098	12.1
Off-to-On	53,128	3.45	7,594,457	142.9	33,739	38.1
Total Trips Included	*200,242*	*13.0*	*17,864,590*	*89.2*	*123,249*	*36.9*
Panel B: Removed from Sample for Analysis						
On-to-On	1,330,386	86.36	49,928,048	37.5	413,163	18.6
Out of U.S. Federal waters	9,927	0.64	471,037	47.5	3,457	20.9
Total Trips Excluded	1,340,313	87.0	50,399,085	37.6	416,620	18.7
Total (A+B)	**1,540,555**	**100.0**	**68,263,675**	**44.3**	**539,870**	**21.0**

See Figure A.9, Figure A.10, and Figure A.11 for heatmaps of onshore to onshore trips.

We highlight a few notable characteristics. First, of the approximately 1.5 million helicopter trips in the 2017 FAA NextGen data (Harris 2019), approximately 13 percent, or 200,000, are candidates to support offshore operations. Over 85 percent of the trips fly from onshore-to-onshore locations. Discussions with individuals in the oil and gas industry suggest that is rare for a helicopter to be utilized for transporting people or materials from onshore-to-onshore locations, and therefore we remove these for purposes of further analysis. Less than 1 percent of trips begin or end beyond Federal waters, and these are also removed from the sample.[19]

We identify approximately 77,000 onshore-to-offshore trips with a total distance of 8.2 million kilometers flown. The average trip was 106.6 kilometers and took 58.5 minutes to complete. Approximately 70,000 offshore-to-offshore trips are identified with a total distance of 2 million kilometers flown and an

[19] Note that a helicopter flying south might leave the sample in Federal waters but continue south. We are unable to track the aircraft after it leaves the red box show in Figure 1, and therefore these trips are labeled outside of Federal waters.

average flight time of 12 minutes. Approximately 53,000 offshore-to-onshore trips are identified, with an average distance of 142.9 kilometers and an average flight time of 37 minutes.

Comparing these summary statistics yields a few observations. First, there are not the same number of onshore-to-offshore and offshore-to-onshore trips. As confirmed by communication with industry, helicopters can come in and out of range based on the location of the transceivers, especially pre-2020 when the system became fully operational. Second, onshore-to-offshore and offshore-to-onshore trips have longer average flight durations and trip lengths (compared to offshore-to-offshore trips) as they require traveling over land as well as State waters to reach (or return from) Federal offshore waters. Offshore-to-offshore trips involve travel between sites in offshore Federal waters that are often clustered, leading to shorter trip durations and lengths. Third, notice that the number of offshore-to-offshore trips is similar to the number of trips coming to and from offshore. Based on discussions with industry, typically, a helicopter will leave its location on land in the morning and then make multiple stops offshore before heading back to shore later in the day. Thus, this not only suggests that coverage is not universal but also that we are less likely to observe a trip that is offshore-to-offshore.

To further assess plausible coverage of the FAA NextGen data, we next compare to the Helicopter Safety Advisory Conference (HSAC) data discussed in Chapter 3.4. It is important to note that (1) HSAC also does not have 100 percent coverage of offshore operations and (2) there are some trips that are candidates for supporting offshore operation from FAA NextGen that will be removed in subsequent analysis when indexing to offshore activity. Nonetheless, we find the comparison of the relative size of these two data sets constructive.

Analyzing Table 7, we see that there were approximately 492,000 trips reported in the HSAC data for 2017, while our analysis with the FAA NextGen data identifies approximately 200,000 trips. Thus, the FAA data have about 41 percent of the coverage of HSAC .[20] More on this will be discussed in Chapter 5.

Table 7 also shows summary statistics for the total flight hours. The FAA NextGen data have 65 percent coverage of the total flight hours, in contrast to 41 percent coverage of trips. This is because the average flight time of a trip identified in the FAA NextGen data is 36.9 minutes, compared to just 23 minutes in the HSAC data.

Table 7. Comparison of FAA NextGen and HSAC Summary Statistics (2017)

Trip Type	Trips	Flight Hours	Average Flight Time (minutes)
HSAC	491,697	188,799	23.0
FAA NextGen	200,242	123,249	36.9
FAA Percent Coverage	**40.7%**	**65.3%**	

Altogether, information from Table 6 and Table 7, alongside anecdotal information from industry, reveals the following conclusions. First, the FAA NextGen data are less likely to identify an offshore-to-offshore trip than a trip originating or ending from an onshore location. We are told in industry conversations this is likely because there is better coverage of transceivers onshore and that aircraft fly at higher altitudes from location to location. Second, because trips originating or ending on an onshore location fly longer distances and have longer flight times, extrapolating summary statistics from Table 6 to estimate broader impacts should be done with caution.

[20] Recall that we define a trip as takeoffs + landings/2.

To further assess the coverage of the FAA NextGen data, Table 8 presents summary statistics of the altitude observed at the beginning (i.e., takeoff) and end (i.e., landing) of the polylines (i.e., trips) constructed (see Chapter 3.1). We present the average, median, standard deviation, minimum, and maximum altitude in feet for each trip type.

There are a few notable observations from Table 8. First, the average altitudes of takeoffs and landings from an onshore location are lower. Thus, this is evidence that there is better coverage onshore than offshore, which is consistent with prior observations discussed from Table 6 and Table 7 and discussions with industry. Second, analysis of the summary statistics shows that the distribution of altitudes for takeoffs and landings is right skewed; for each trip type and for both takeoffs and landings, the average is greater than the median, and the standard deviation is greater than the average. Third, the minimum and maximum altitude observed is 150 feet and 6,000 feet, respectively, for all trip types. While not shown here, these are the minimum and maximum altitudes listed across the entire NextGen data. Fourth, the median altitude observed for all takeoffs and landings offshore are 550 feet or greater. For perspective, the highest structure in the Gulf of Mexico's tallest point is approximately 350 feet above sea level.[21] Thus, the median takeoff and landing altitude observed offshore is higher than the plausible upper bound of what is feasible.

Table 8: Altitude Summary Statistics for Takeoffs and Landings by Trip Type

Trip Type	Average	Median	Std. Dev.	Minimum	Maximum
Panel A: Takeoff Location					
Onshore-to-Offshore	642	500	692	150	6,000
Offshore-to-Offshore	1,083	675	1,184	150	6,000
Offshore-to-Onshore	1,039	550	1,340	150	6,000
Panel B: Landing Location					
Onshore-to-Offshore	2,137	1,125	2,183	150	6,000
Offshore-to-Offshore	1,071	625	1,211	150	6,000
Offshore-to-Onshore	447	200	693	150	6,000

Altogether, these insights from Table 8 show that the aircrafts are unlikely to be observed in the data immediately upon takeoff and landing, especially offshore. Thus, there is some time between takeoff and landing that we are not observing. This will downward bias the estimated flight distance and flight times presented in Table 6. This will also be important to consider when indexing helicopters to offshore activity, as a helicopter could be supporting activity within a lease block but enters or exits the sample outside of the lease block for which the activity is being supported. This will be important to consider in Chapter 5 where this helicopter activity is indexed to offshore activity.

Caveats aside, we will utilize this detailed NextGen data to estimate the broader relationship between offshore activity and helicopter trips. We believe that these data are useful in doing so, but such an analysis should be aware of the appropriate interpretation of analysis. Future analysis utilizing data from 2020 or later (after the system has been mandatory for a period of years) will likely yield more precise results. Nonetheless, we will proceed with the 2017 data and make appropriate adjustments to account for incomplete data coverage. A future analysis with data post-2020 can update and improve the accuracy of the estimates presented in this research.

[21] Petronius Compliant Tower is the tallest oil platform in the world, with a water depth of 1,754 feet and a pinnacle height of 2,100 feet. Thus, the structure peaks at approximately 350 feet above sea level.

4.2. TIMING OF ACTIVITY

Next, we seek to understand the timing of helicopter operations. We present results (1) across hours of the day, (2) days of the week, and (3) months of the year. This information will be useful in further assessing how representative the NextGen data are temporally and also provide insights more broadly into how helicopter operations support offshore activity.

4.2.1. Hour of Day

Figure 2 illustrates the average daily takeoffs and landings supporting offshore oil and gas operations by the hour of the day. As expected, there are relatively few helicopter operations occurring at night. Takeoffs begin in the 5AM hour and increase until the 7AM hour. 7AM is the busiest takeoff hour of the day. Landings then increase with a lag to takeoffs, with landings peaking at the 8AM hour. Takeoffs and landings decline somewhat in the 9AM hour and then level off until the 3PM hour, falling off significantly after 5PM. All-in-all these flight times look realistic.

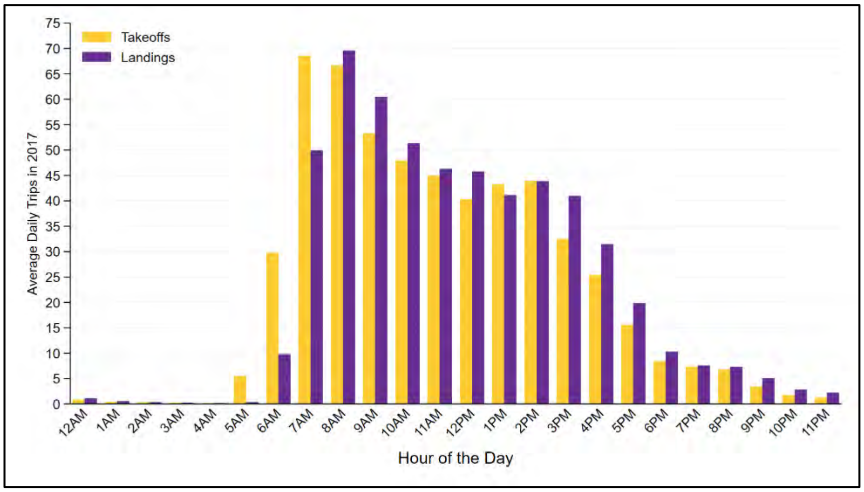


Figure 2. Takeoffs and Landings by Hour of Day.
Source: Harris 2019 and authors' computations.

4.2.2. Day of Week

Figure 3 illustrates the average daily takeoffs and landings by the day of the week. As expected, there are fewer events during weekends. The number of takeoffs and landings is relatively consistent across the week, with the lightest day of the week on Friday.

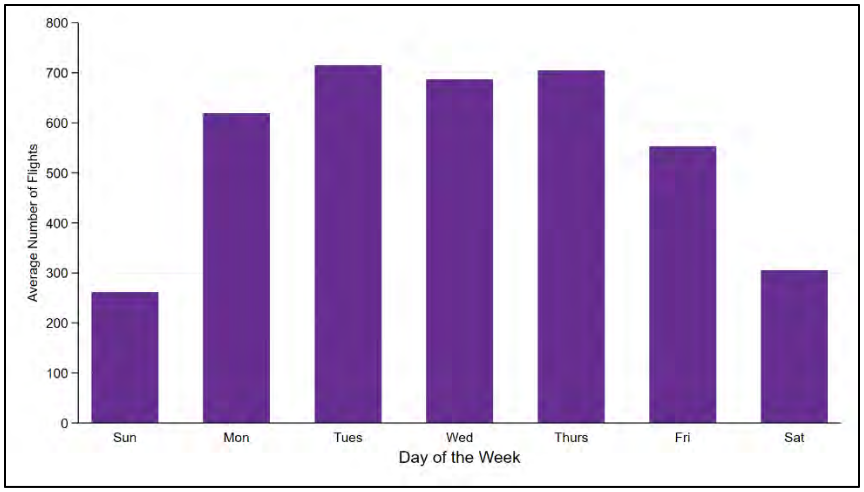


Figure 3. Flights by Day of Week.
Source: Harris 2019 and authors' computations.

4.2.3. Month of Year

Figure 4 illustrates the average daily helicopter trips across the months of the year. This is particularly important to consider because, as discussed in Chapter 3.1.1, helicopters gradually installed ADS-B Out equipment from 2017 to 2019. Thus, if we observe a significant increase in trips as the year progresses, this would need to be taken into account while indexing this activity to offshore operations, as activity early in the year might have less coverage than activity late in the year. Fortunately, this is not what we see in Figure 4. Trips oscillate between 500 and over 600 for most of the year before seeing significant reductions in activity starting in November and more pronounced in December.

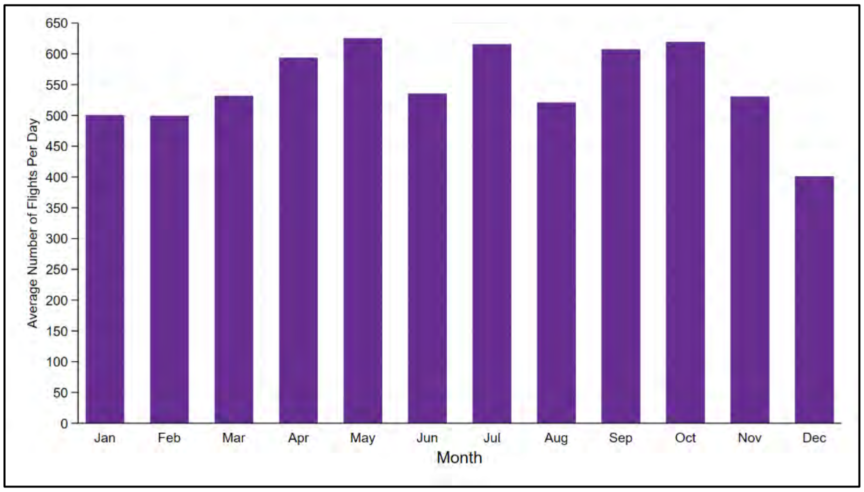


Figure 4. Flights by Month of Year.
Source: Harris 2019 and authors' computations.

4.2.4. Spatial Distribution

Finally, the spatial distribution of helicopter activities normalized to the area of each geographic unit is shown in Figure 5, Figure 6, and Figure 7. Figure 5 shows the distribution of takeoff locations both onshore and in the Gulf of Mexico. Likewise, Figure 6 shows the distribution of landing locations both onshore and in the Gulf of Mexico. The normalized distance flown by each geographic unit is shown in

Figure 7. As discussed in Chapter 3.2, the geographic units for offshore areas are lease blocks and reclassified State water areas. The geographic units for onshore areas include census block groups for the States of Texas, Louisiana, Mississippi, Alabama, and Florida, with appropriate modifications to identify State waters. Corresponding spatial distribution of onshore-to-onshore trips is shown in Chapter 5 in Figure A.9, Figure A.10, and Figure A.11.

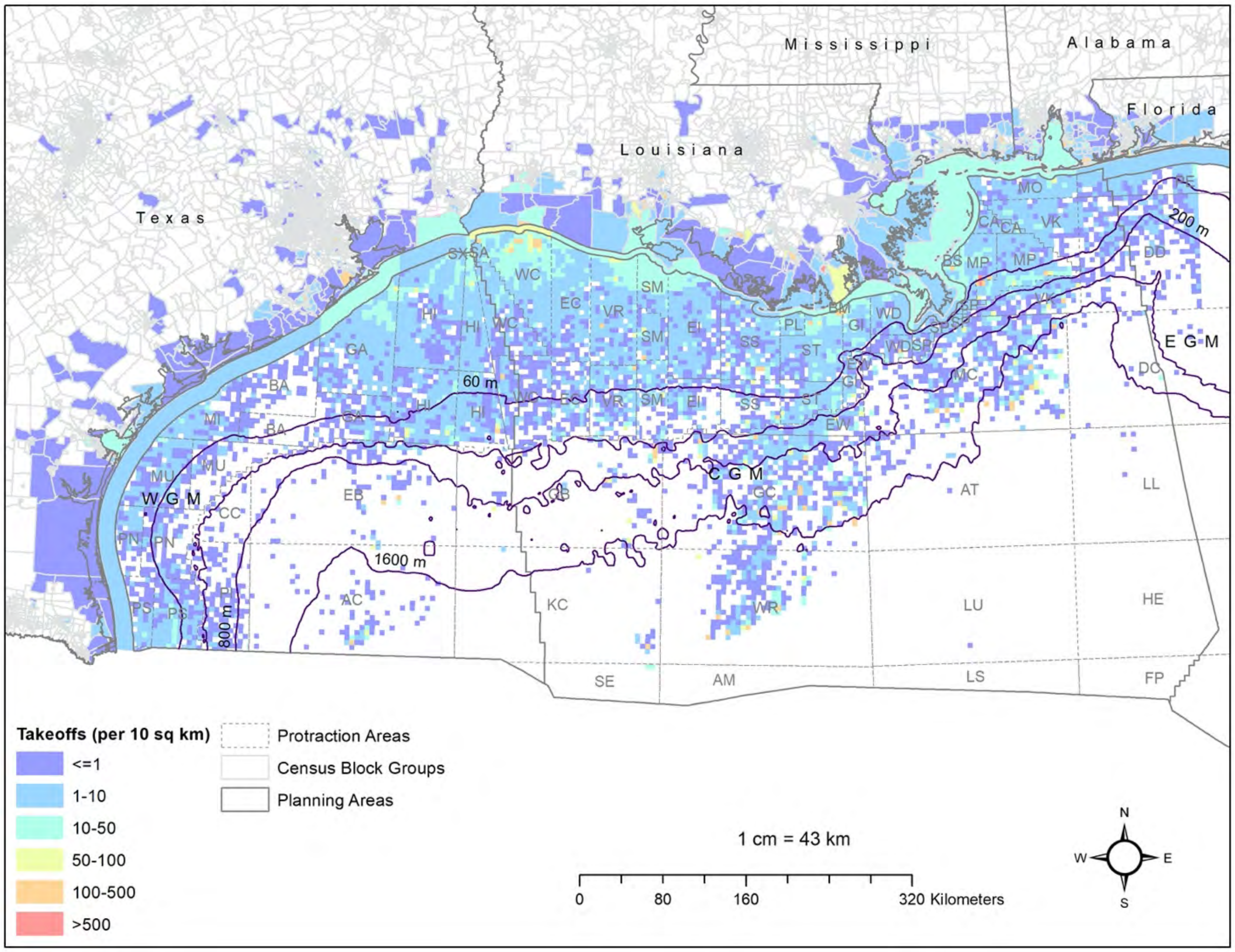


Figure 5. Spatial Distribution of Helicopter Trip Origins.
Source: Harris 2019 and authors' computations.

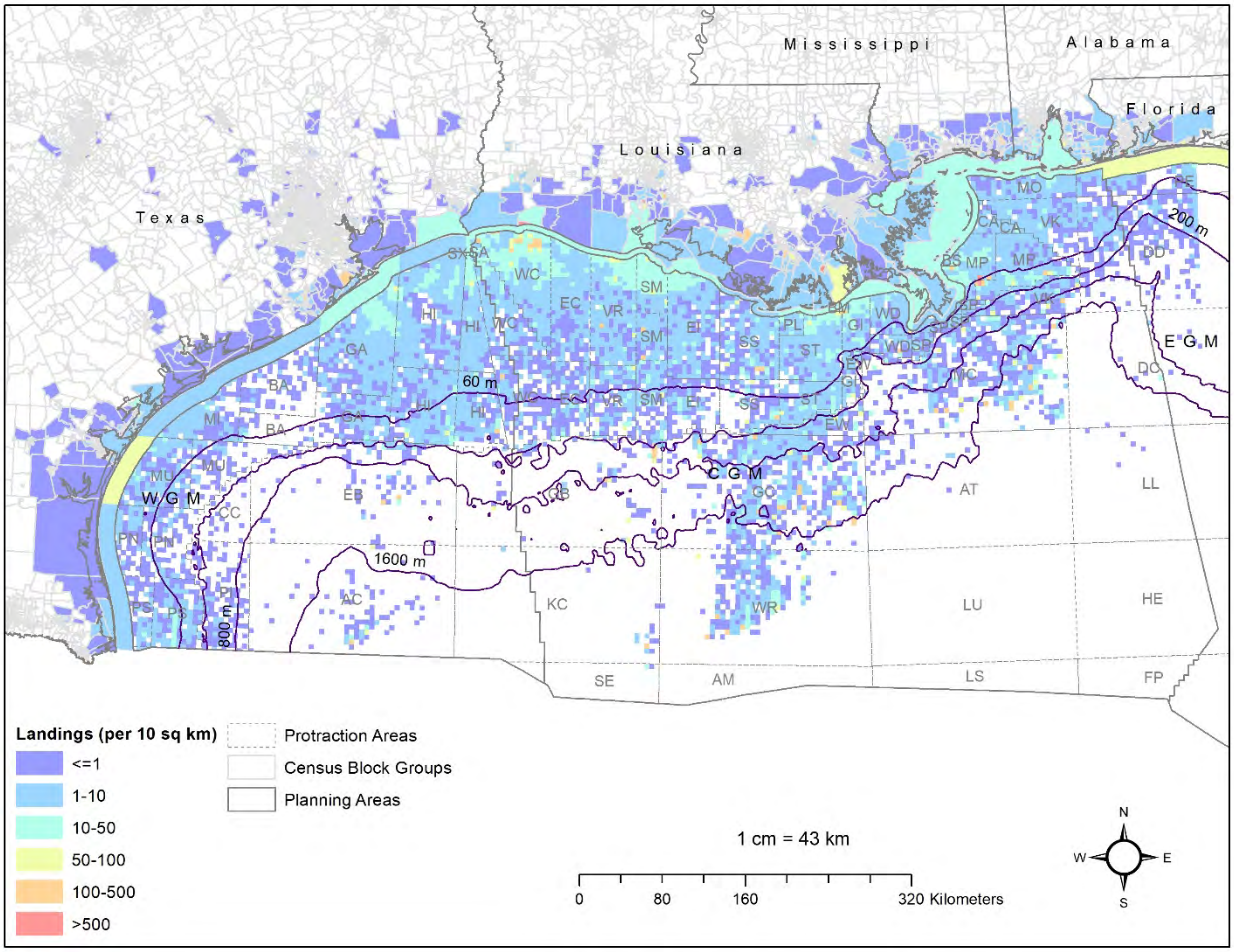


Figure 6. Spatial Distribution of Helicopter Trip Destinations.
Source: Harris 2019 and authors' computations.

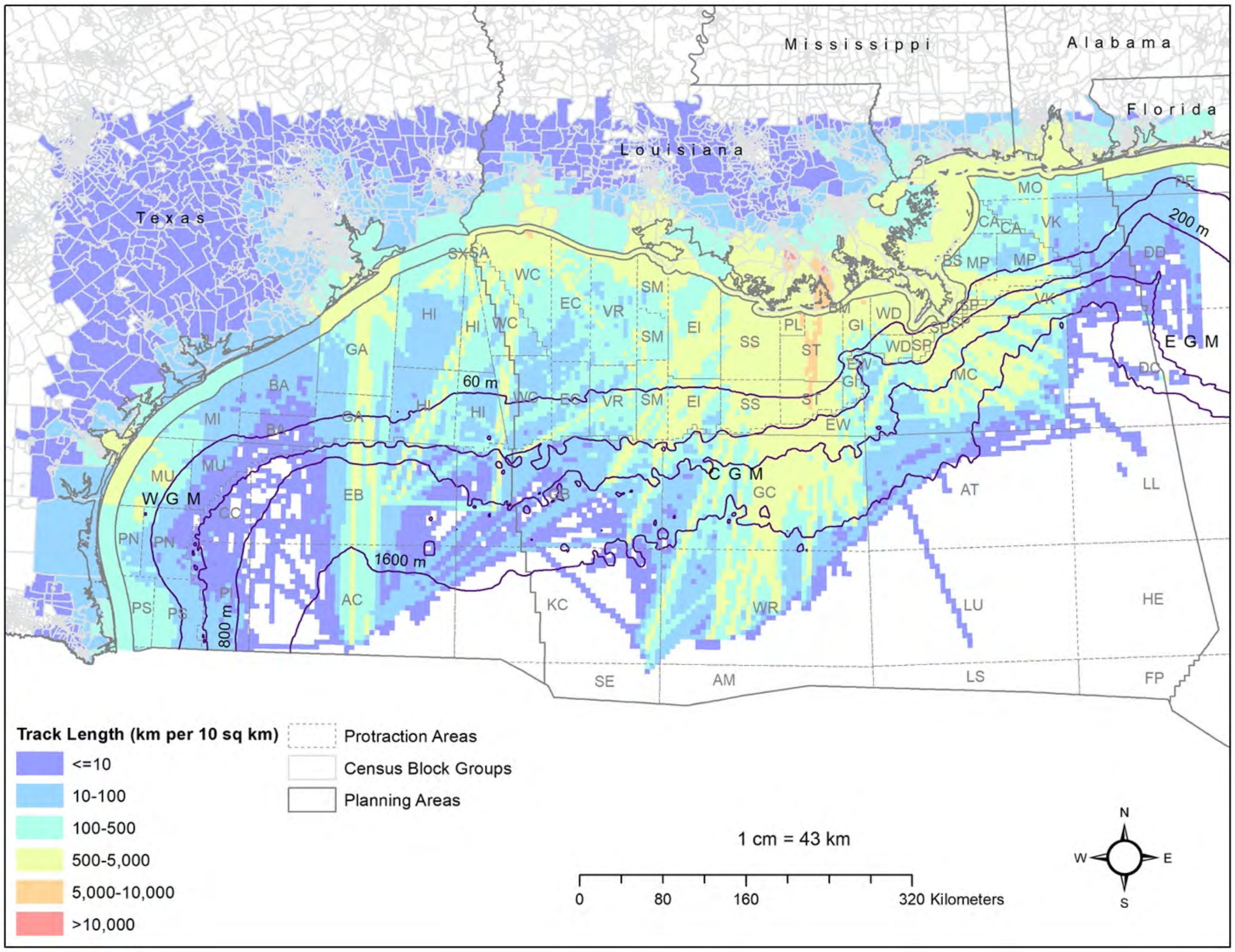


Figure 7. Heat Map: Normalized Helicopter Distance Flown.
Source: Harris 2019 and authors' computations.

5. INDEXING HELICOPTER FLIGHTS TO OFFSHORE ACTIVITY

This chapter examines how helicopter flights support offshore oil and gas activity. Chapter 5.1 begins by outlining how helicopter trips are assigned to offshore activities. The empirical methodology used to estimate the duration of helicopter support and number of helicopter trips required for each oil and gas activity is discussed in Chapter 5.2. Finally, estimation results are provided in Chapter 5.3.

5.1. MATCHING HELICOPTER FLIGHTS TO ACTIVITY

We begin with the 2017 NextGen flight data summarized in Table 6 and make a few further modifications to eliminate trips that are not likely associated with the offshore oil and gas activities in Federal waters. First, all trips that takeoff or land in State waters, but for which no takeoff or landing occurs in Federal waters are not considered in further analysis, as the focus for BOEM is trips supporting oil and gas activities in Federal waters. This reduces the total number of flights considered hereafter from 200,242 (shown in Table 6) to 130,902 trips.

Next, a small number of trips could not be indexed to an oil and gas activity and were removed from the analysis because neither their takeoff nor landing locations are in geographic proximity to oil and gas activities that occurred in Federal waters during 2017. Specifically, trips that neither takeoff nor land within 20 kilometers (12.43 miles) of any oil or gas activity are removed. This further reduces the number of trips by 4,648 (3.55% of the remaining trips) to 126,254. The results do not qualitatively change if the distance limit is changed to 10, 15, or 25 kilometerse. Table 9 shows the regression sample in context relative to both the HSAC data and FAA NextGen data.[22] Because the FAA NextGen data do not provide a complete sample of the helicopter activity, as discussed in Chapter 3.1.2, an assumption must be made to escalate the observed sample to the population for purposes of quantifying the estimated helicopter activity needed to support offshore operations. To do so, we simply divide the total number of trips in 2017 as reported by HSAC by the number of trips in the regression sample.

Table 9. Escalation Factor

Trip Type	Trips	Share of HSAC
HSAC (2017)	491,697	100%
FAA NextGen Offshore Sample	200,242	40.7%
Regression Sample Merged with Federal Offshore O&G Activity	126,254	25.7%
Escalation Factor	**3.89**	

This approach may either over or underestimate the true escalation factor needed in a number of ways. For instance, the HSAC data do not provide universal coverage and it includes trips supporting State waters. Because this analysis focuses on activity in Federal waters, these State water trips are outside the scope of this paper. The net effect of these and other factors is ambiguous. Nonetheless, we will utilize an escalation factor of 3.89 for further empirical analysis.

As discussed in Chapter 4.1, the ADS-B system is unlikely to track a helicopter once it goes below approximately 1,500 feet, especially if it is not in geographic proximity to a transceiver. For this reason, we next reassigned the remaining trips to the nearest lease block with oil or gas activity during 2017, with some stipulations. Landing area may be changed if the landing location is in Federal offshore waters and the nearest activity occurred in a different lease block than the landing. Likewise, the takeoff area may be

[22] Compare to Table 3.

changed if the takeoff location is in Federal offshore waters and the nearest activity occurred in a different lease block than the takeoff. In total, 34,079 landing locations are reassigned, and 35,780 takeoff locations are reassigned. All takeoff and landing reassignments are, at most, 20 kilometers from the original area due to the restrictions discussed in the previous paragraph.

Further data restrictions were also considered but did not qualitatively change the results. For example, restrictions that required the oil and gas activity to have occurred in either the 12 weeks prior or 12 weeks after the takeoff or landing for the trip to be eligible for lease block reassignment removed only a small number of trips from the data and had no substantive effect on the estimation results. Other time windows including 24 or 36 weeks also generated similar results. Likewise, reassigning takeoff and landing areas to the second closest activity if the nearest activity occurred more than 12 weeks before or after the trip did not alter the results (the second closest activity usually occurred within the same lease block as the nearest).

The data are then transformed into a balanced panel data set covering geographic areas over time. Each geographic unit (i.e., lease block or census block group) has an observation for each week. Variables are created to indicate the number of takeoffs, landings, and trips (defined as takeoffs plus landings divided by two) that occurred in each geographic area during each week. There are also indicator variables for each oil and gas activity discussed in Chapter 3.3, indicating if that activity occurred within a geographic unit during that week. Finally, there are continuous variables that indicate the number of each oil and gas activity occurring in a geographic unit during each week (e.g., how many exploratory wells drilled in a lease block in the first week of the year).

The balanced panel data set covers 53 weeks (several trips have nighttime takeoffs on December 31, 2016, and landings on January 1, 2017) and 2,117 distinct geographic areas for a total of 112,201 observations. On average, 1.3 takeoffs, 1.1 landings, and 1.2 trips occur in each area every week.

5.2. Empirical Methodology

Three distinct empirical methodologies were used to examine the effects of varying oil and gas operations on helicopter trips. The type of activity occurring, as well as the frequency that an activity occurs, determine the most appropriate methodology. Event studies are used for activities that are hypothesized to have temporary helicopter support (e.g., drilling exploratory wells). These activities can be categorized as exploration, development, abandonment, and decommissioning activities. A standard ordinary least squares (OLS) regression is used to examine how more permanent production activities (e.g., manned producing structure or auxiliary structures) are supported by helicopters. Several activities occur very infrequently (e.g., only two platforms and a single floating structure were installed in 2017) in the data, making the external validity of estimates from either of these methodologies subject to concern. In these cases, additional visual steps are taken to determine potential support duration, and OLS is used to estimate the level of support, though the estimates should be interpreted with caution. Transportation and trunkline installations also occurred with relatively low frequencies, i.e., only four during 2017. The results for transportation/trunkline installation are the same whether the event study methodology or the regression methodology for low-frequency events is used. All cumulative effects for each methodology are censored at zero. This assumes that no activity has a negative effect on helicopter trips.

5.2.1. Exploration, Development, and Abandonment Activities Methodology

The number of helicopter trips undertaken to support exploration, development, and abandonment activities were estimated using event studies. These event studies were not estimated in cases where there were insufficient numbers of activity occurrences. To be included in this empirical exercise, each activity must have been conducted at least three separate times during 2017.

The event studies are a flexible framework that nonparametrically estimate the number of additional helicopter trips occurring in the weeks leading up to and after each activity. The estimating equation is,

$$y_{it} = \alpha + \sum_{\tau=-T}^{T} \beta_\tau \cdot Z_{i\tau} + \mu \cdot X_{it} + \delta_i + \theta_t + \epsilon_{it} \qquad (1)$$

Where the variables of interest are the event time indicators $Z_{i\tau}$, a set of dummy variables indicating the number of weeks prior to or post an activity's beginning or end date. Whether the beginning or end date is used is determined by the activity and available data. For example, spud dates are used for drilling wells while removal dates are used for removing platforms. The dependent variable y_{it} is the number of helicopter trips that occurred in area i and week t. X is a matrix of controls that includes the number of producing oil and gas structures in an area. δ_i is an area fixed effect that controls for idiosyncratic characteristics of geographic units that do not vary over time (e.g., the underlying geology of a lease block). θ_t is a week-of-sample fixed effect that controls for time vary shocks that affect the entire Gulf of Mexico, such as macroeconomic shocks and fluctuations in the prices of oil or gas. ϵ_{it} is an error term clustered at the area level allowing for correlations in the errors within geographic units over time.

In practice, T is set to 12 so that the effects of each activity in the 12 weeks before and 12 weeks after the event are estimated (changing the time window to include more/less weeks or aggregating the data to the monthly level does not qualitatively change the results). $Z_{i\tau}$ is equal to one if an observation is τ weeks after the event and zero otherwise (a continuous variable indicating the feet of line removed/installed is used for gathering and transportation variables). The event time indicator Z_{i-11} is normalized to zero by excluding the indicator from the regression, allowing for each estimated coefficient β to be interpreted as the number of additional helicopters expected each week relative to 11 weeks before the activity. Periods more than 12 weeks before or after the event are binned into the -12 and +12 event indicators, respectively. This means that the +12 indicator can be interpreted as the number of additional helicopters in all weeks more than 11 weeks after the event. Likewise, the -12 indicator is the number of additional helicopters in all weeks more than 11 weeks before the event. A separate event study is estimated for each activity.

The duration of helicopter support is determined by the sum of event time indicators that are significant at the 10% level. For example, three significant event time coefficients suggest that helicopter operations supported the activity for 3 weeks. The total number of helicopter operations required is calculated as the sum of the significant event time indicators. Upper and lower bounds of these estimates are calculated by summing the lower and upper bounds of the 90% confidence intervals. The effects are then normalized to average weekly helicopter trips by dividing the cumulative effect by the support duration.

5.2.2. Producing Structures Methodology

Unlike the activities estimated in the prior chapter, producing structures do not have clear-cut start or end times, with the exception of structures installed or removed in 2017. The continuous nature of these structures lends itself to standard OLS regression techniques. The average number of weekly helicopter trips for manned producing oil structures, manned producing gas structures, unmanned producing oil structures, and unmanned producing gas structures, as well as idle and auxiliary structures present during 2017, are therefore estimated using the following equation,

$$y_{it} = \alpha + \beta \cdot X_{it} + \theta_t + \epsilon_{it} \qquad (2)$$

Where y is again the number of helicopter trips in an area i and week t. X is now a matrix containing continuous variables indicating the number of each structure type in each area and week. θ_t is again a week-of-sample fixed effect that controls for time vary shocks that affect the entire Gulf of Mexico, such as macroeconomic shocks and fluctuations in the prices of oil or gas. ϵ_{it} is an error term clustered at the area level allowing for correlations in the errors within geographic units over time. An area fixed effect is not included in this model because it would remove all time invariant characteristics of the geographic units. This means that identification of the effects would only come from lease blocks that changed the number of structures during the sample. In other words, the identification would largely come from the installation or removal of structures while here we are interested in the average effect of already having a structure in place.

In this empirical specification, each structure is implicitly assumed to be serviced by helicopters for 52 weeks during a year. Though structures are on average active for slightly less than the entire year (between 47 and 50 weeks, depending on structure type), helicopter trips do not appear to change during the inactive weeks. This suggests that, even while inactive, these structures require similar levels of helicopter support.

5.2.3. Infrequent Activities Methodology

Several activities were undertaken very infrequently during 2017; only two platforms were installed and only one floating structure was installed during this period. The low occurrence of the activities precludes the use of event studies to investigate how they are supported by helicopter operations. They are also hypothesized to be activities not supported year-round by helicopter operations, necessitating estimates of support duration.

The effects are estimated using the following equation:

$$y_{it} = \alpha + \mu \cdot \omega_{it} + \beta \cdot X_{it} + \theta_t + \epsilon_{it} \qquad (3)$$

Where X is again a matrix controlling for the number of producing gas and oil structures in an area i and week t, y is the number of helicopter trips, θ_t is a week-of-sample fixed effect, and ϵ_{it} is an error term clustered at the area level. Now the variable of interest is ω_{it}, indicating the week the activity of interest occurred in an area. The coefficient μ therefore indicates the deviation in the number of helicopters seen in that area and week relative to all other areas that week.

These regressions alone cannot determine the duration of helicopter support for these activities. For these activities, a visual inspection of helicopter trips around the time of the activity can lend evidence for support durations.

Two activities did not occur in the Gulf of Mexico during 2017. Specifically, no caissons were installed and no floating structures were removed. Because we did not observe these activities, we are unable to make credible estimates as to the level of helicopter operations required to support them. Looking at the estimates for caisson removals may provide some suggestive evidence for how caisson installations are supported. The estimates for installing floating structures are unlikely to be helpful in determining how floating structure removals are supported because only one floating structure was installed during 2017.

5.3. Estimation Results

5.3.1. Exploration, Development, and Abandonment Activities Results

Using the methodology described in Chapter 5.2.1, drilling exploratory wells, installing subsea completions, plugging and abandoning wells, and removing wells are all found to be supported by helicopter operations, regardless of water depth. Installing gathering lines, installing transportation/trunklines, removing gathering lines, removing transportation/trunklines, plugging and abandoning subsea completion, removing caissons, and removing platforms are all estimated to require zero helicopter trips per week, regardless of water depth. Drilling developmental wells is found to require helicopter support in deeper water, i.e., 200-800 meters or 1600 meters+.

Figure 8 and Figure 9 provide an illustration of the event study methodology for an activity that is supported by helicopter operations and one that is not, respectively. Figure 8 presents the results from an event study examining how helicopter operations support the drilling of exploratory wells. The points plotted can be interpreted as the number of additional helicopter trips experienced in that week relative to 11 weeks before the spud date of the exploratory well. For example, the point at event time 0 tells us that approximately 5 additional helicopter trips occurred in weeks that an exploratory well was spudded relative to the 11 weeks before the spud date. The start and end points (event time -12 and 12) are binned to include all weeks outside of the figure. In other words, the event time indicator for -12 and 12 depict the effects for all weeks more than 12 weeks before or more than 12 weeks after the spud date, respectively. Bars stemming from the point estimates depict 90% confidence intervals. Confidence intervals that *do not* intersect the dashed line at zero are statistically significant at the 10% level. The number of statistically significant point estimates is interpreted as the length of helicopter support for each activity. The statistically significant point estimates themselves are summed together and divided by the number of significant estimates to calculate average weekly effects. Upper and lower bounds are calculated in a similar fashion, but point estimates are replaced by the upper and lower bounds of the confidence intervals, respectively. There are 15 point estimates that are statistically significant in Figure 8, indicating a support duration of 15 weeks. The average weekly effect, after applying the escalation factor, can be seen in Table 10. The average number of weeks that helicopter operations increased support for drilling exploratory wells was 13.2 trips/week with a range of 6.5 to 19.89 trips/week.

Figure 9 presents results from an event study examining how helicopter operations support plugging and abandoning subsea completions. As can be seen from the figure, no point estimates are statistically significant at the 10% level. This indicates no support from helicopter operations for plugging and abandoning wells.

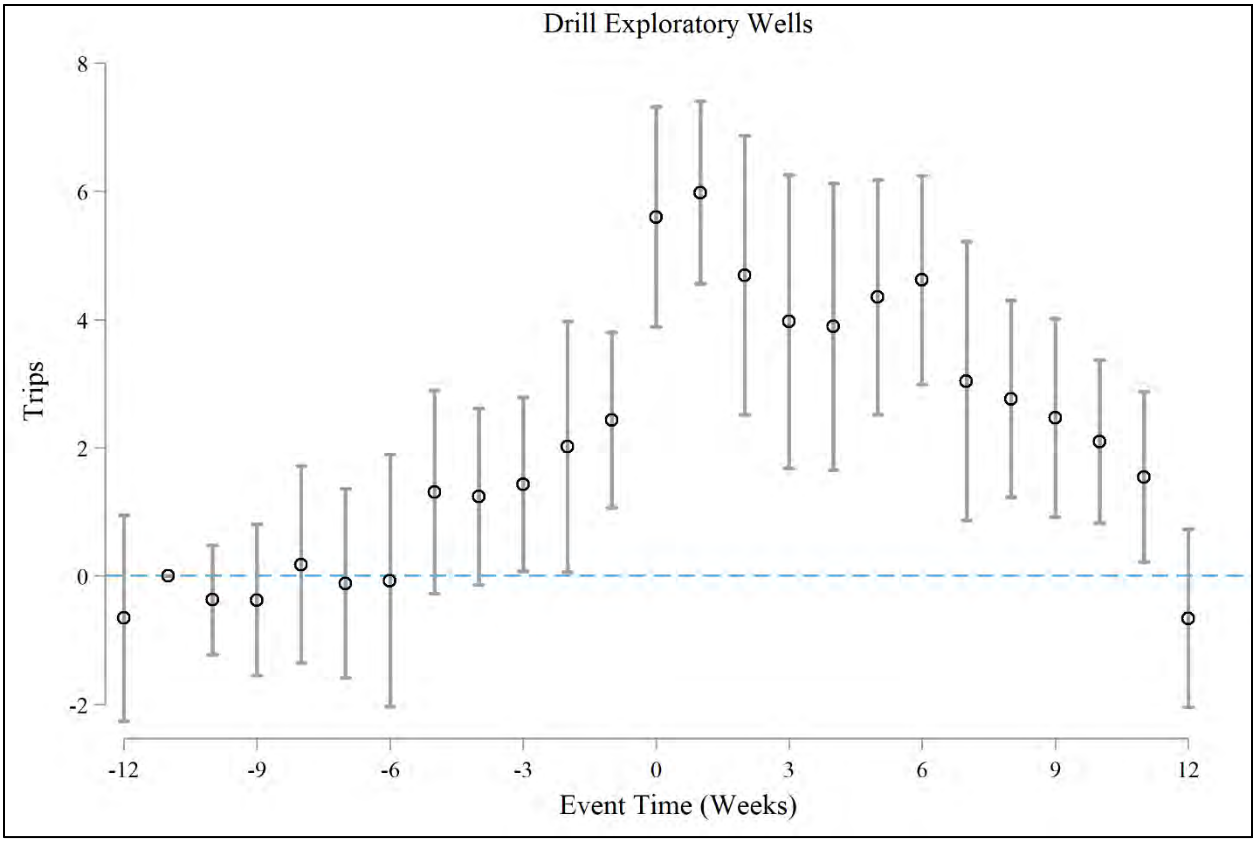


Figure 8. Event Study, Helicopter Trips Supporting Exploratory Well Drilling.
Source: Harris 2019 and authors' computations.
Notes: Point estimates show the effect of drilling an exploratory well relative to the effect 11 weeks prior to the spud date of the well. Bars stemming from the point estimates illustrate 90% confidence intervals. Confidence intervals that do not intersect the dashed line are significant at the 10% level. Standard errors are clustered at the geographic-unit level. Periods more than 12 weeks before or after the spud date are binned into the -12 and 12 periods, respectively. Escalation factors not applied.

Table 10. Average Weekly Helicopter Trips for Oil and Gas Activities

Activity Type	Support Duration (Weeks)	Low Estimate	Mid Estimate	High Estimate
Panel A: All Depths Pooled				
Drill exploratory well	15	6.50	13.20	19.89
Drill development well	0	0.00	0.00	0.00
Install caisson	0	0.00	0.00	0.00
Remove caisson	0	0.00	0.00	0.00
Install platform	7	0.72	4.34	7.96
Remove platform	0	0.00	0.00	0.00
Install floating structure	20	54.28	55.05	55.81
Remove floating structure	0	0.00	0.00	0.00
Install gathering/flowlines (thousands of feet)	0	0.00	0.00	0.00
Remove gathering/flowlines (thousands of feet)	0	0.00	0.00	0.00
Install transportation/trunklines (thousands of feet)	0	0.00	0.00	0.00
Remove transportation/trunklines (thousands of feet)	0	0.00	0.00	0.00
Install subsea completion	10	2.64	12.26	21.87
Producing gas structure	52	0.44	1.48	2.52
Producing gas structure/manned	52	0.19	2.58	4.97
Producing oil structure	52	0.00	0.00	0.42
Producing oil structure/manned	52	1.56	2.68	3.81
Idle structures	52	0.00	0.00	0.02
Auxiliary platform	52	0.42	1.42	1.69
Plug and abandon well	3	0.00	0.27	1.29
Plug and abandon subsea completion	0	0.00	0.00	0.00
Panel B: Depths >800 Meters				
Drill exploratory well	14	8.48	15.42	22.35
Drill development well	1	0.56	17.69	34.82
Install floating structure	20	54.28	55.05	55.81
Remove floating structure	0	0.00	0.00	0.00
Install gathering/flowlines (thousands of feet)	0	0.00	0.00	0.00
Remove gathering/flowlines (thousands of feet)	0	0.00	0.00	0.00
Install transportation/trunklines (thousands of feet)	0	0.00	0.00	0.00
Remove transportation/trunklines (thousands of feet)	0	0.00	0.00	0.00
Install subsea completion	10	3.85	13.88	23.90
Producing gas structure/manned	52	17.67	18.39	19.11
Producing oil structure/manned	52	16.61	20.76	24.92
Idle structures	52	0.00	0.68	1.70
Auxiliary platform	52	0.00	0.57	1.28
Plug and abandon well	8	0.00	3.60	7.87
Plug and abandon subsea completion	3	0.49	12.09	23.69

Note: Escalation factor of 3.89 used for all estimates. Support durations not impacted by escalation factor. Zero estimates indicate a statistically insignificant effect.

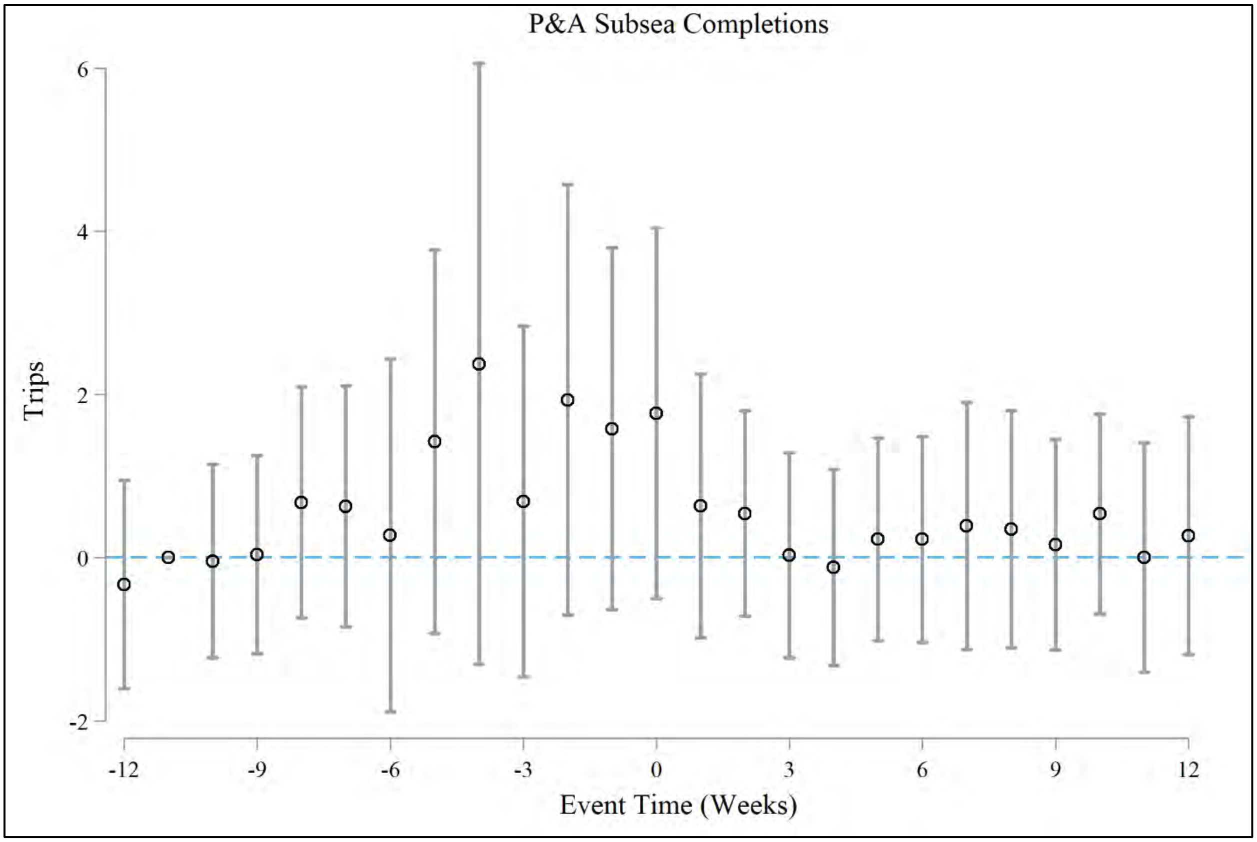


Figure 9. Event Study: Helicopter Trips Supporting Plugging and Abandonment of Subsea Completions.

Source: Harris 2019 and authors' computations.

Notes: Point estimates show the effect of plugging and abandoning (P&A) subsea completions relative to the effect 11 weeks prior to the P&A date. Bars stemming from the point estimates illustrate 90% confidence intervals. Confidence intervals that do not intersect the dashed line are significant at the 10% level. Standard errors are clustered at the geographic-unit level. Periods more than 12 weeks before or after the P&A date are binned into the -12 and 12 periods, respectively. Escalation factors not applied.

When examining how helicopter trips support activities at varying depth bins, we first examine whether the effects for each depth bin are statistically different from the effects for all other depth bins. This is done by separating the events that occurred in one depth bin from the others (e.g., the effects for drilling exploratory wells in 0-60 meters of water are estimated separately from the effects for drilling exploratory wells in >60 meters of water). A t-test is then performed to examine if the sum of coefficients for the specified depth bin are statistically different from the sum of coefficients from all other depth bins pooled. If the coefficients are statistically different at the 10% level, the effects for that activity and depth bin are estimated separately. If the null hypothesis that the linear combination of coefficients are the same is not rejected, no activities occurred in that depth bin, or there are too few (or no) observations of the activity in the depth bin, the average effect for that activity is assumed.

Results from the event study methodology can be seen in Table 11. This table presents support durations, low estimates, middle estimates, and high estimates. Table 11 also reports estimates for activities in varying depth bins including 0-60 meters, 60-200 meters, 200-800 meters, 800-1600 meters, and 1600 meters+.

Table 11. Weekly Helicopter Trips for Exploration, Development, Abandonment, and Decommissioning Activities by Varying Depth

Activity Type	Support Duration (weeks)	Low Estimate	Mid Estimate	High Estimate
Drill Exploratory Well				
0-60 m	15	6.50	13.20	19.89
60-200 m	15	6.50	13.20	19.89
200-800 m	15	0	0	0
800-1600 m	14	6.50	13.20	19.89
1600 m+	14	6.50	13.20	19.89
Drill Development Well				
0-60 m	0	0	0	0
60-200 m	0	0	0	0
200-800 m	14	0	0	1.76
800-1600 m	0	0	0	0
1600 m+	22	10.78	11.20	11.62
Install Platform				
0-60 m	7	0.72	4.34	7.96
60-200 m	7	0.72	4.24	7.96
200-800 m	7	0.72	4.24	7.96
Install Subsea Completion				
0-60 m	10	2.64	12.26	21.87
60-200 m	10	2.64	12.26	21.87
200-800 m	13	0	0	3.12
800-1600 m	10	2.64	12.26	21.87
1600 m+	9	3.20	13.34	23.48
Install Floating Structure				
200-800 m	20	54.28	55.05	55.81
800-1600 m	20	54.28	55.05	55.81
1600 m+	20	54.28	55.05	55.81
Plug and Abandon Well				
0-60 m	3	0	0.27	1.29
60-200 m	3	0	0.27	1.29
200-800 m	3	0	0.27	1.29
800-1600 m	4	0	3.30	6.93
1600 m+	7	3.58	9.77	15.96

Note: Escalation factor of 3.89 used for all estimates. Support durations not impacted by escalation factor. Zero estimates indicate a statistically insignificant effect. The average activity estimate is used when no events occur in a depth bin.

5.3.2. Producing Structures Results

Table 10 also provides estimates for the effects of manned producing oil structures, manned producing gas structures, unmanned producing oil structures, unmanned producing gas structures, idle structures, and auxiliary platforms. Producing gas structures appear to require more helicopter trips on average than oil producing structures. Manned structures, not surprisingly, require more helicopter trips than unmanned structures. Table 12 further examines how helicopters support these activities at varying depth bins.

Producing structures in deeper waters require additional helicopter support regardless of production type. Estimates range from lows of 0 trips a week for each structure for water depths 0-60 meters to over 30 trips per week per structure for manned oil producing structures in water depths 1600 meters+.

Idle and auxiliary platforms appear to require fewer trips than producing counterparts. Idle structures require very few or zero trips in many instances while auxiliary platforms require a nontrivial amount of helicopter trips/week in some estimates (e.g., over 6 trips/week for platforms in 60-200 meters).

5.3.3. Infrequent Activities Results

Installing platforms and installing floating structures are the only activities that fall in this category. Their support durations were determined visually by inspecting Figure 10 and Figure 11.

The helicopter trips for the two lease blocks that experienced platform installations during 2017 can be seen in Figure 10. The two lease blocks are MP270 and SM71, and both platforms were installed toward the end of the year. SM71 only experienced a handful of helicopter trips during 2017, and there is no noticeable increase in trips around the installation date. MP270 saw helicopter trips in waves throughout the year, but there is a large increase after the platform installation. This increase appears to last for approximately 6-7 weeks. Based on this visual inspection we conclude that platform installations may be supported by helicopter activities for 0-7 weeks.

The regression results presented in Table 10 suggest that 4.34 helicopters/week are used in platform installations. The 90% confidence interval is relatively wide, ranging from near zero (0.72) to almost eight helicopter trips per week. This wide range is due to the small amount of activity that took place in 2017.

The helicopter trips for the lease block that experienced a floating structure installation during 2017, i.e., Block GC468, can be seen in Figure 11. The installation occurred slightly before the midway point of the year. Prior to installation, the lease block saw between zero and five trips per week, but these numbers increased in the 5-6 weeks before installation. The average number of trips remained elevated throughout the remainder of 2017 after the installation. While the average number of trips was higher, there were still weeks with relatively few trips (3-5 trips/week, before escalation). Based on this visual inspection we conclude that platform installations may be supported by helicopter activities for approximately 20 weeks.

The regression results presented in Table 11 suggest that 55.05 helicopters/week are used in floating structure installations. The 90% confidence interval ranges from 54.28 to 55.81.

We do not present estimates of these effects for most depth bins separately because the activities are so infrequent. It was also not possible to estimate effects for caisson installations and removing floating structures due to data limitations.

Though not reported here, a similar approach was also used to estimate the effects of the four transportation/trunkline installations on helicopter trips. These results were not qualitatively different from those estimated using the event study methodology.

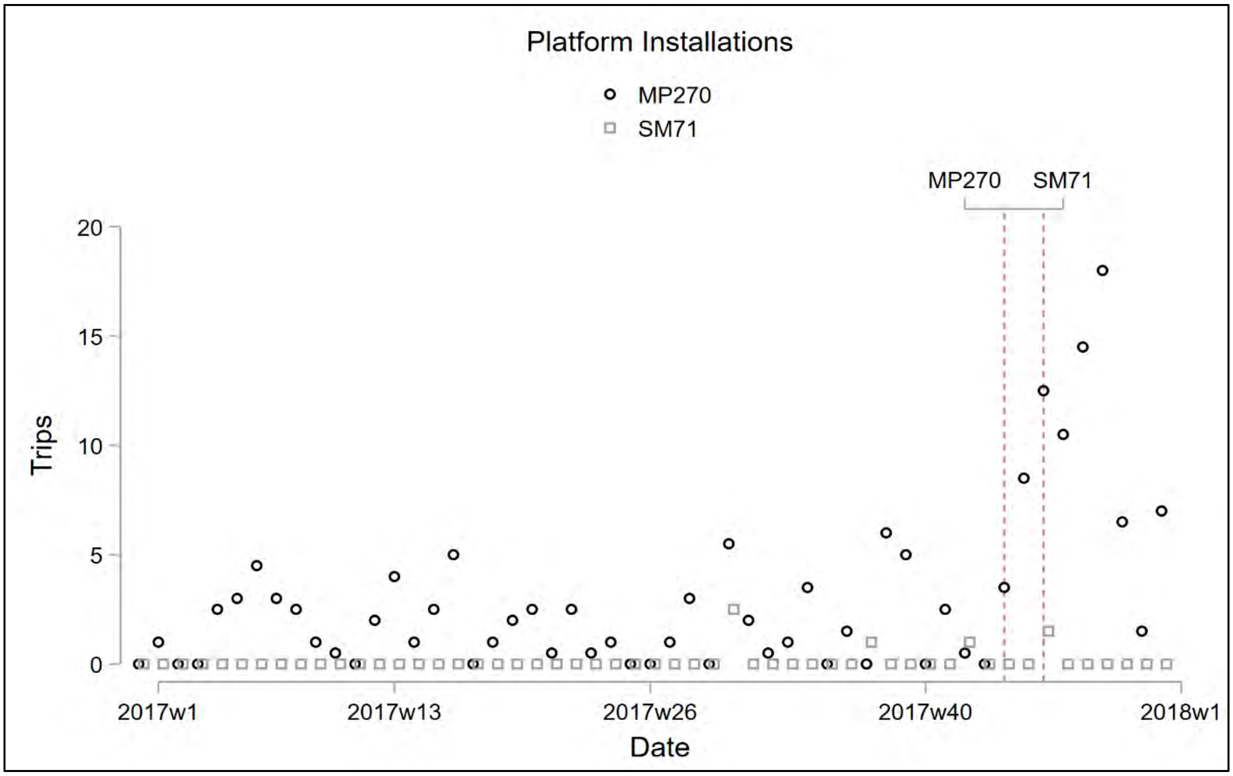


Figure 10. Helicopter Trips and Platform Installations.
Source: Harris 2019 and authors' computations. Note: Escalation factors not applied. Red dotted line is the date of installation.

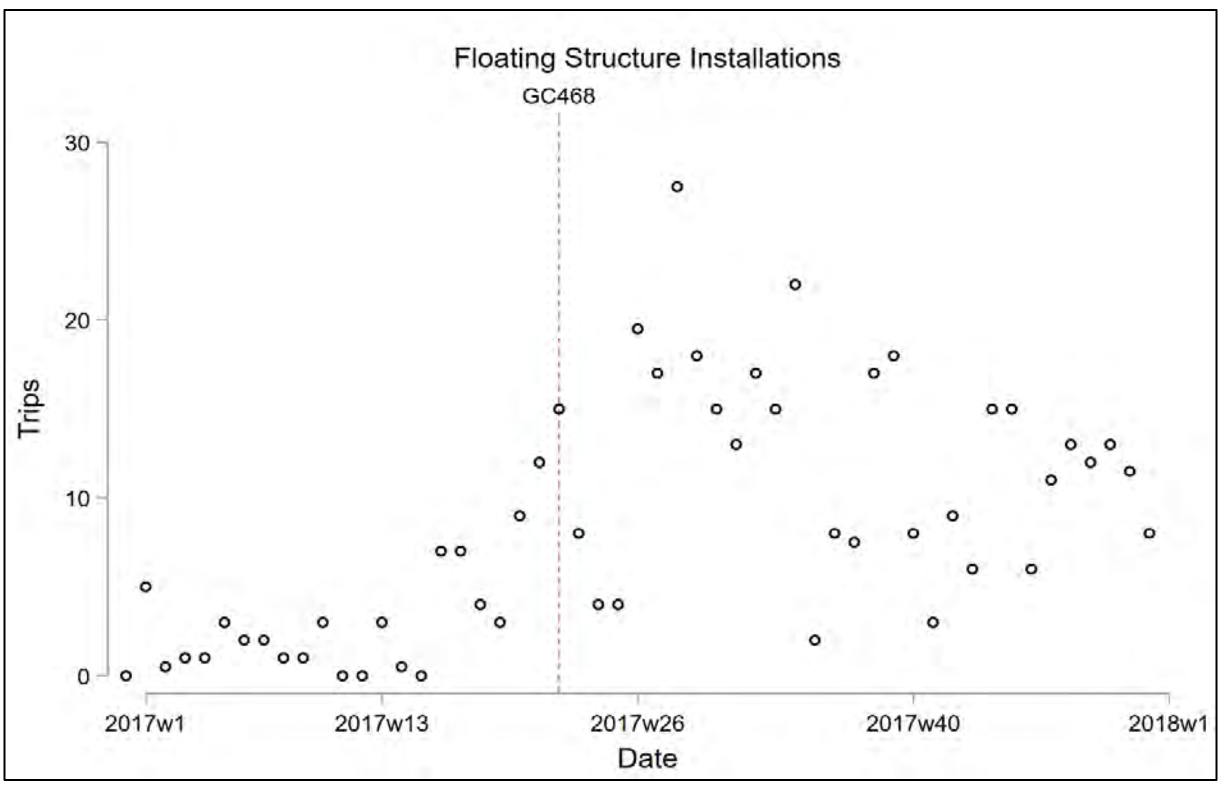


Figure 11. Helicopter Trips and Floating Structure Installations.
Source: Harris 2019 and authors' computations. Red dotted line is the date of installation.

Table 12. Weekly Helicopter Trips Supporting Structures by Varying Depth

Activity Type	Support Duration (weeks)	Low Estimate	Mid Estimate	High Estimate
Producing Gas Structures – Unmanned				
0-60 m	52	0.54	1.58	2.62
60-200 m	52	0	0	0
200-800 m	52	0.44	1.48	2.52
800-1600 m	52	0.44	1.48	2.52
1600 m+	52	0.44	1.48	2.52
Producing Gas Structures – Manned				
0-60 m	52	0	2.59	6.04
60-200 m	52	0	0.30	3.57
200-800 m	52	0	0.28	3.19
800-1600 m	52	17.47	18.16	18.84
1600 m+	52	0.20	2.58	4.98
Producing Oil Structures – Unmanned				
0-60 m	52	0	0	0.34
60-200 m	52	0	1.16	3.54
200-800 m	52	0	0	0.42
800-1600 m	52	0	0	0.42
1600 m+	52	0	0	0.42
Producing Oil Structures – Manned				
0-60 m	52	0	0.44	1.57
60-200 m	52	0	0	0
200-800 m	52	5.75	9.01	12.27
800-1600 m	52	13.80	19.10	24.40
1600 m+	52	16.57	23.42	30.28
Idle Structures				
0-60 m	52	0	0	0.02
60-200 m	52	0	0.15	1.90
200-800 m	52	0	0	0
800-1600 m	52	0	0	0.02
1600 m+	52	0	0.55	1.58
Auxiliary Structures				
0-60 m	2	0.42	1.05	1.68
60-200 m	2	6.65	8.15	9.64
200-800 m	2	0.42	1.42	1.69
800-1600 m	52	0.42	1.42	1.69
1600 m+	2	0	0.52	1.23

Note: Escalation factor of 3.89 used for all estimates. Support durations not impacted by escalation factor. Zero estimates indicate a statistically insignificant effect.

5.4. Estimated Aggregate Activity

Finally, we apply estimates of helicopter trips needed to support specific activity to historical activity that is observed. We present empirical estimates of the total number of helicopter trips needed to support offshore oil and gas operations in Federal waters in the most recent 5 years, i.e., from 2015 to 2019. To do this, we combine data on the amount of offshore activity show in Table 5 combined with empirical point estimates presented in Table 13.

On average over these past 5 years, we estimate that 152.5 thousand helicopter trips are taken per year to support offshore oil and gas operations in Federal waters. The low to high activity estimates range from 77.6 thousand to 243.4 thousand per year.

Also noticeable in Table 13 is that the number of helicopter trips has declined over these years from a middle range of 166.6 thousand in 2015 to 138.8 thousand in 2019. This is a reduction of approximately 16.7 percent over a 5-year period. This general decline in helicopter activity is corroborated when examining the HSAC trips data that have been declining over this time period.

Table 13. Aggregate Activity Estimates

Year	Low Activity	Mid Activity	High Activity
2015	80,801	166,605	269,957
2016	80,731	159,542	255,502
2017	74,019	147,121	235,579
2018	78,233	150,644	236,850
2019	74,334	138,772	219,168
Yearly Average	77,624	152,537	243,411

It is important to compare data in Table 13 to the data reported by HSAC. Specifically, our estimates of helicopter activity are significantly lower than the HSAC data. For comparison, Table 9 shows that HSAC reports 491.7 thousand trips in 2017, which is significantly higher than the range of estimates of 74.0 thousand to 235.6 thousand. There are several factors that may bias our results and might describe some of the difference. Unfortunately, we are unable determine in net the direction of bias because these factors likely have countervailing effects on our estimates.

The first factor is statistical precision that will downward bias results. Either more years of coverage with more offshore activity and/or a higher share of coverage from the FAA NextGen data would increase the precision of point estimates. Recall that the NextGen system did not become mandatory until 2020, and we are using data from 2017. Discussion with helicopter companies reveal that helicopters were just beginning to install appropriate equipment in 2017. To see how this can bias estimates downward, consider the event study presented in Figure 8. Though there is a notable visual increase in helicopter trips in weeks -4 and -5 (i.e., 4-5 weeks before the activity), the point estimates are not statistically significant. The increase in helicopter trips for these 2 weeks is therefore not included in our estimates. While it would be feasible to widen our confidence intervals, we are already at the lower end of conventional statistical significance. Widening the confidence intervals further would result in possible "false positives" while not entirely eliminating the issue at hand (e.g., a new set of point estimates may become "almost" significant at the 15% or 20% levels). For this reason, a future study utilizing data post-2020 when all aircraft have installed appropriate equipment to be included in the NextGen system might improve the accuracy of results.

Second, recall that, due to not complete coverage of the NextGen data in 2017, we chose to scale point estimates based on the HSAC data (as shown in Table 9). Admittedly, our scaling factor for the HSAC data is ad-hoc due to the nature of the data but informed by all available information. Scaling point estimates by the HSAC data may bias our estimates upward or downward. First, the HSAC data include support for offshore operations in State waters or might also include trips that are outside of our study area (e.g., trips support oil and gas operations off the coast of Mexico). Second, the HSAC data do not include all helicopter operators supporting offshore activities. Specifically, the most recent 2018 statistical report states that nine helicopter operators responded to the survey. Conversations with industry reveal that this includes the vast majority of flights but is not 100 percent coverage.

In net, results of this research produce our best estimate of helicopter trips needed to support offshore oil and gas infrastructure in Federal waters given all information available.

6. CONCLUSIONS

Helicopters are critical to supporting offshore oil and gas operations. In this report, we conduct detailed analysis of the FAA Next Gen data that include approximately 200,000 helicopter trips that plausibly support offshore oil and gas operations. These data are merged with offshore oil and gas operational data obtained from the BSEE data center. We then quantifiably estimate the number of helicopter trips needed to support specific offshore oil and gas operations. The purpose of these estimates is to assist BOEM in identifying impacts of OCS activity on the human, marine, and coastal environments.

We find that several exploration, development, and abandonment activities are supported by helicopter operations. Drilling exploratory wells, installing subsea completions, and plugging and abandoning wells are all supported by helicopters, regardless of depth. Drilling developmental wells was also found to be supported by helicopters at some depths. All producing structures, idle structures, and auxiliary structures were found to utilize helicopter support at some depths. Though they occurred infrequently in 2017, we also found suggestive evidence that the installation of platforms and floating structures was supported by helicopter activity.

From 2015 to 2019, there were an estimated average of 152.5 thousand helicopter trips per year taken to support offshore activity in the Federal Gulf of Mexico. Over the 5-year period, these trips sum to over 760 thousand trips.

APPENDIX A: DATA PROCESSING

In Chapter 3.1, we discuss the extensive data processing conducted on the FAA NextGen data. Notable steps are presented in this appendix. An overview of the data process is shown in Figure A.1.

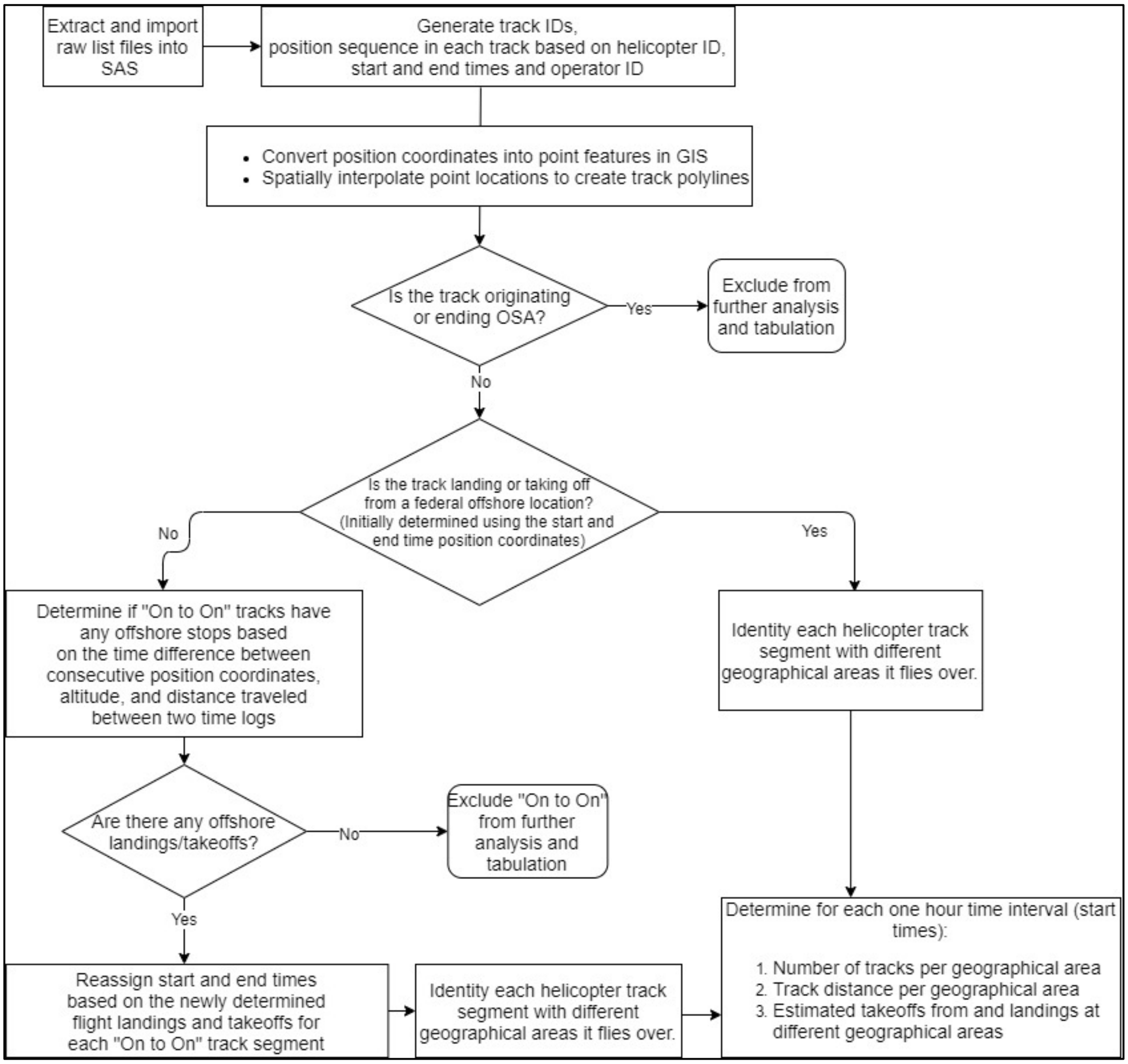


Figure A.12. Data Processing.
Description of helicopter data processing.

We present three examples of flight paths that before processing would be denoted as onshore-to-onshore trips and how the decision rules classified these as either supporting offshore operations (and therefore being considered for further analysis) or not.

The flight depicted in Figure A.2 is an example of an onshore-to-onshore trip. This trip originated from a census block group in Terrebonne Parish, then flew over Louisiana State waters and an offshore area on the way to a census block group in Mobile County. Though this flight flew over offshore areas, both the origin and destination of the flight are onshore. This flight is excluded from analysis because of the onshore origin and destination, and the linear interpolation along with the time, distance and altitude thresholds between consecutive position logs while flying over the offshore area does not indicate that the flight made a stop in an offshore area.

The flight depicted in Figure A.3 is another example of an onshore-to-onshore trip. But unlike the trip in Figure A.2, this trip originated in a census block group in Assumption Parish, flew over an offshore area, and then returned to approximately the same location as the origin. The linear interpolation of this flight indicates that it did indeed make a stop at an offshore area and therefore is included in further analysis. Had this flight been naively classified as “onshore-to-onshore” without spatial interpolation, this flight would have incorrectly been removed from analysis.

The flight depicted in Figure A.4 shows a flight that originated from a census block group in Lafourche Parish and initially traveled towards the Garden Banks area. The linear interpolation indicates that the helicopter made a stop in this area before traveling to the Green Canyon area. From there, the helicopter travels on to the Mississippi Canyon area making two more stops before returning to the initial onshore location. Similar to the flight depicted in Figure A.3, this flight is included in the data because the linear interpolation, along with the time lag between consecutive position coordinates, altitude, and distance traveled between two time logs, indicates that this helicopter made multiple offshore stops despite having the same origin and destination in the raw data.

Figure A.5 in the Appendix illustrates a portion of the study area with distinct spatial unit boundaries, separating onshore regions from State offshore and Federal offshore areas. Since State waters are single geographic entities and are not delineated in units similar to Federal waters (lease blocks), we have extended Federal protraction area boundaries through State waters to coastlines. This scales each State’s offshore areas into several distinct geographies that are more comparable in size to Federal offshore units, but still separate from the Federal waters.

Figure A.6 and Figure A.7 illustrate the difference between the original and revised spatial unit boundaries for the States of Louisiana and Texas respectively. Because portions of some OCS lease blocks cross into State waters, blocks or portion of blocks of the State side of the Federal-State boundary are not included as part of the Federal offshore areas. Furthermore, spatial data on onshore census block groups differ in their definitions across states. The original census block groups layer covers the entirety of State waters for states with offshore boundaries that are 3 nautical miles from the shoreline (e.g., Louisiana), but only a portion of State waters for states that have 9-nautical mile offshore boundaries (e.g., Texas). Originally, all spatial units that are part of the census block group layer, even if they lie in the State water areas are classified as “Onshore.” This designation resulted in all helicopter trips made to or from these regions to other inland census block groups classified as “Onshore” trips and are not included in the final analysis output. The U.S. Census Bureau assigns a special code to census tracts (code values in the 9900s) that specifically delineate large bodies of water. In the revised spatial boundary designation, all census block groups with these tract code values and that lie adjacent to the shoreline are excluded from the onshore census block group classification. Figure A.8 shows the difference in trip classification because of this revised designation of spatial units.

Figure A.9 and Figure A.10 shows the distribution of onshore-to-onshore trip counts across census block groups. The counts are normalized on a per 10 square kilometers basis to adjust for the variance in the size of individual geographic units. Figure A.11 shows the distance flown in each onshore census block group, normalized to the area of each spatial unit.

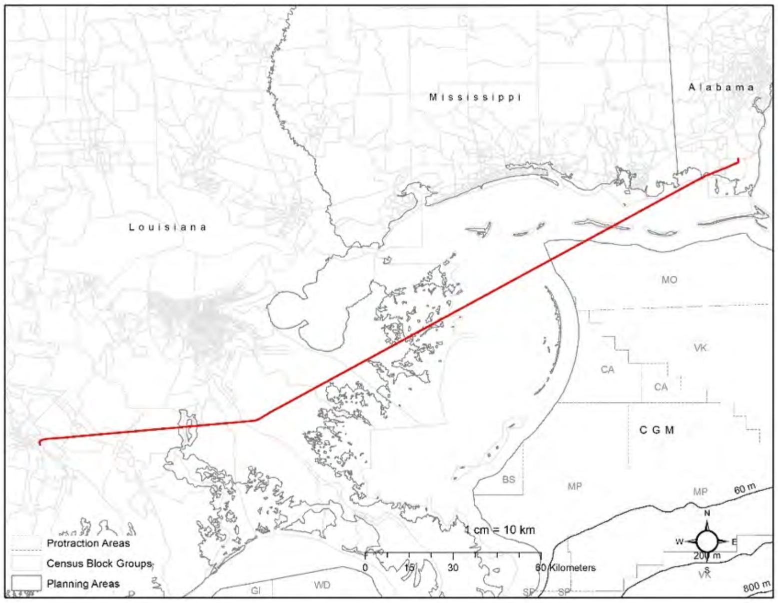


Figure A.2. Onshore to Onshore Flight Path Example.
Source: Harris 2019 and authors' computations.

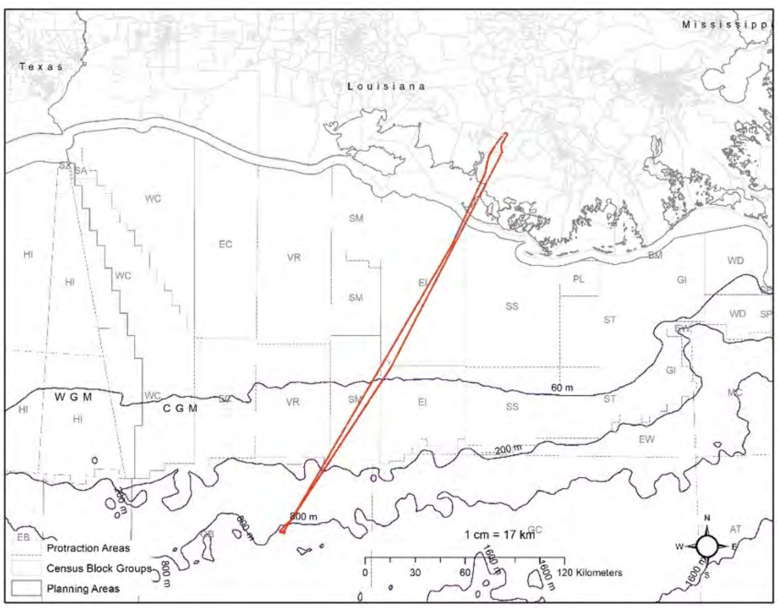


Figure A.3. Onshore to Onshore with Offshore Stop Example.
Source: Harris 2019 and authors' computations.

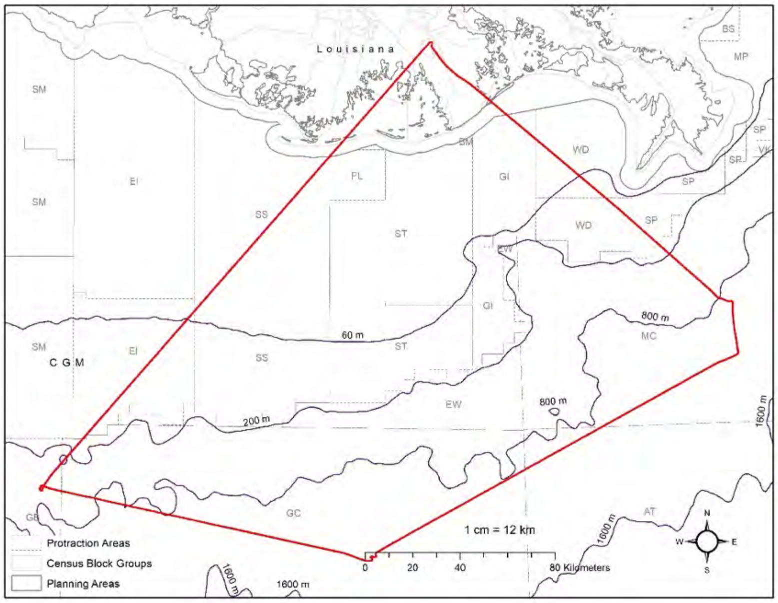
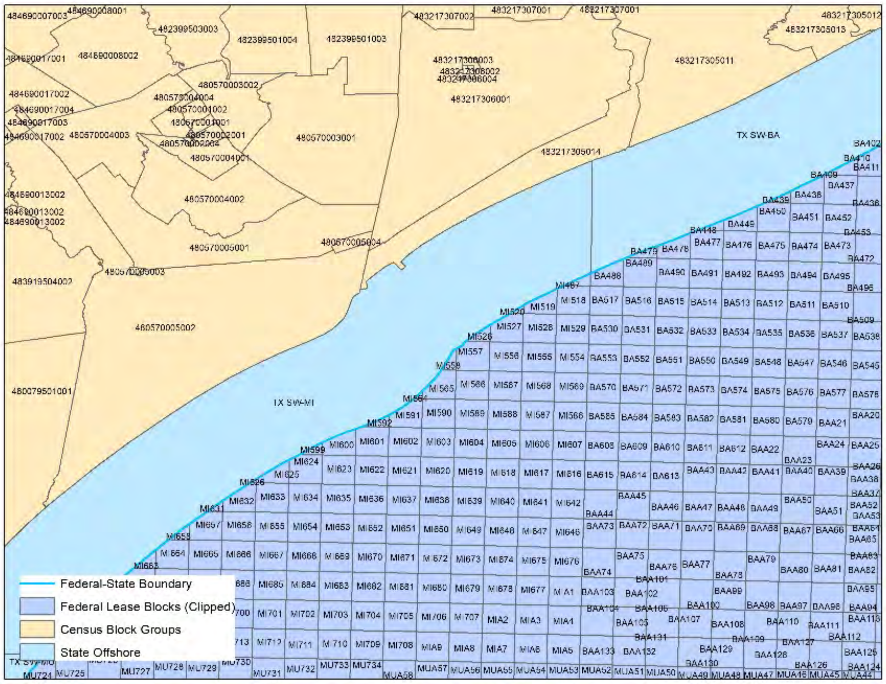
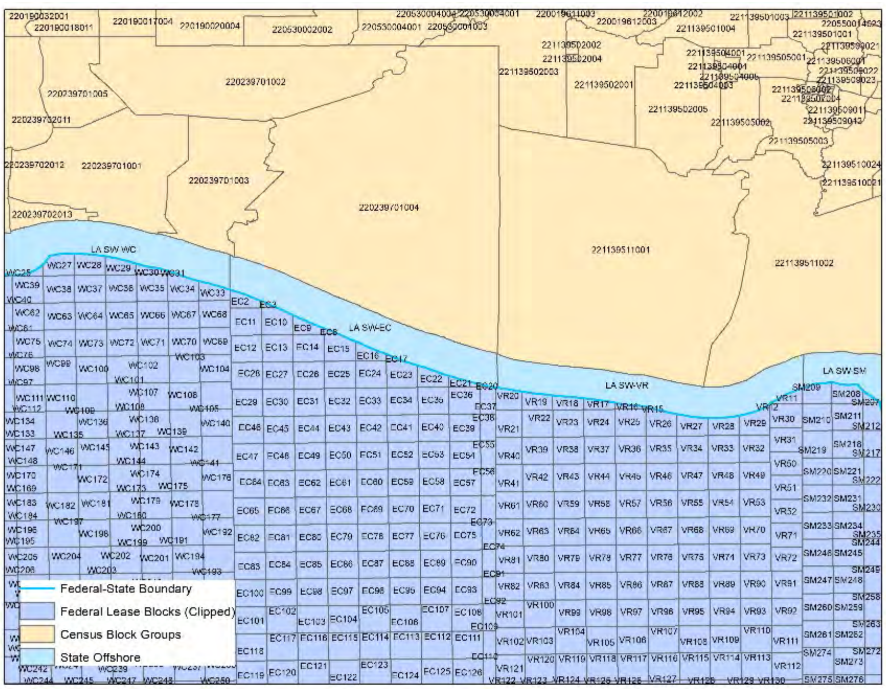


Figure A.4. Onshore to Onshore with Multiple Stops Example.
Source: Harris 2019 and authors' computations.

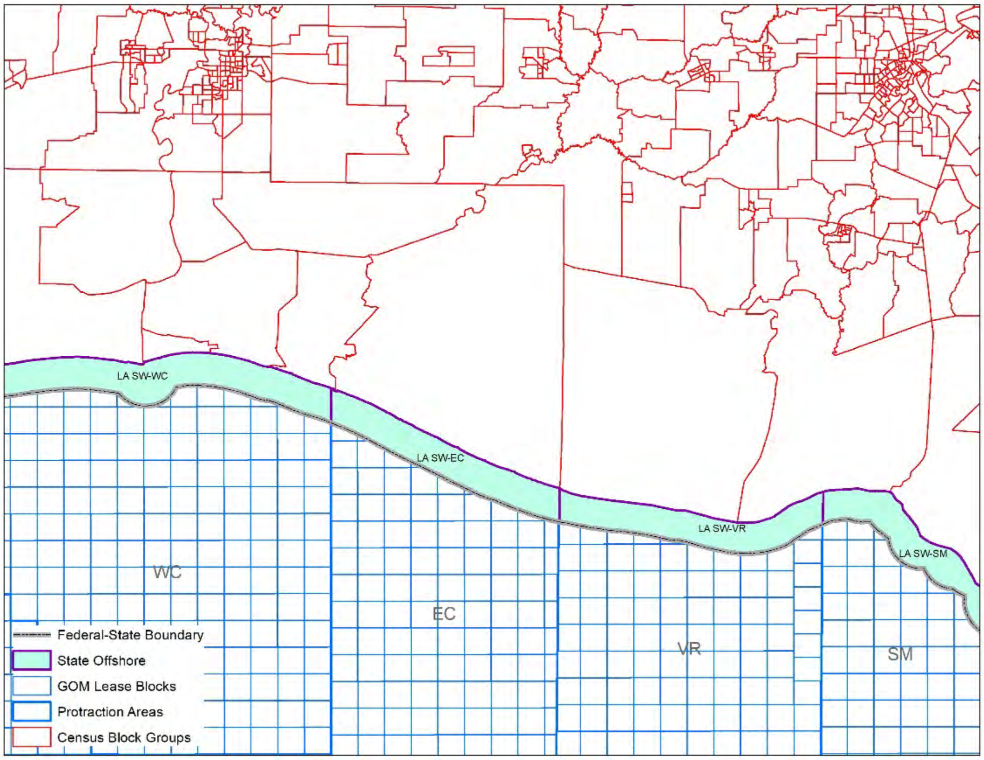


(a) Texas Example

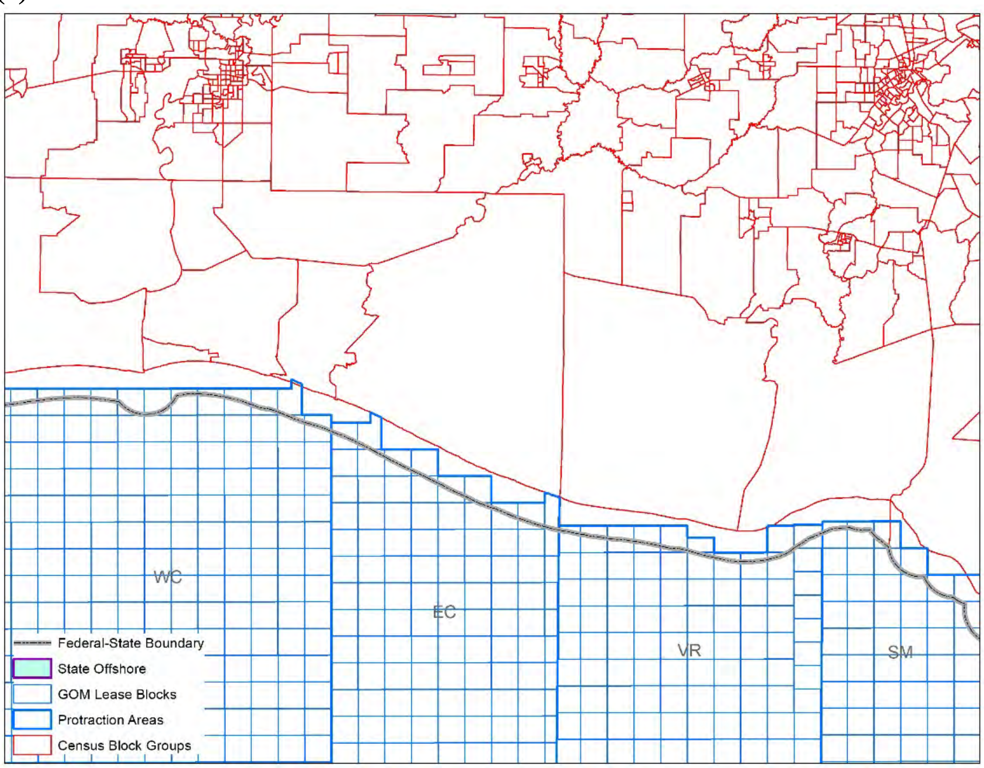


(b) Louisiana Example

Figure A.5. Spatial Unit Boundaries.

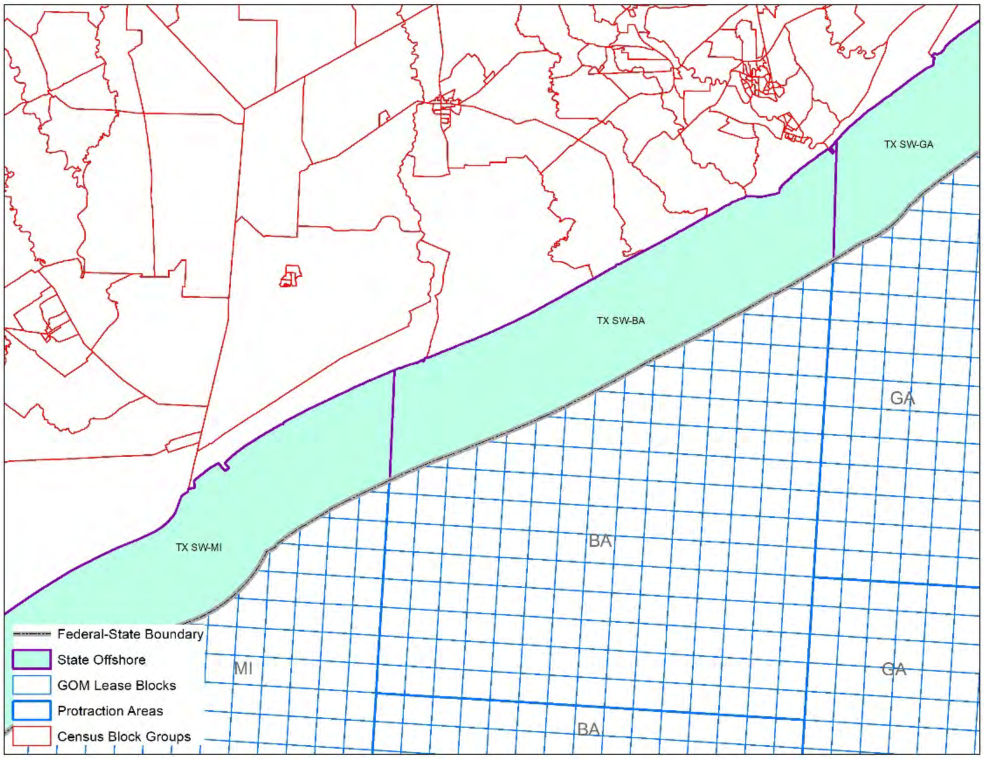


(a) Revised

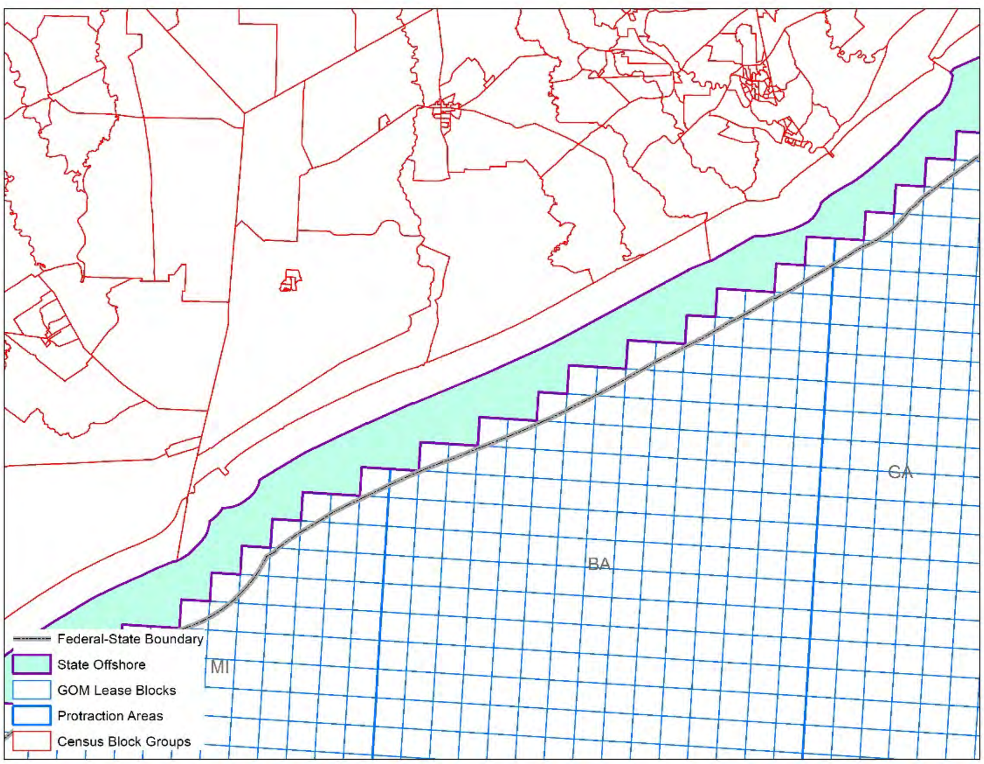


(b) Original

Figure A.6. Louisiana Spatial Boundary Clipping and State Water Delineation Example.



(a) Revised



(b) Original

Figure A.7. Texas Spatial Boundary Clipping and State Water Delineation Example.

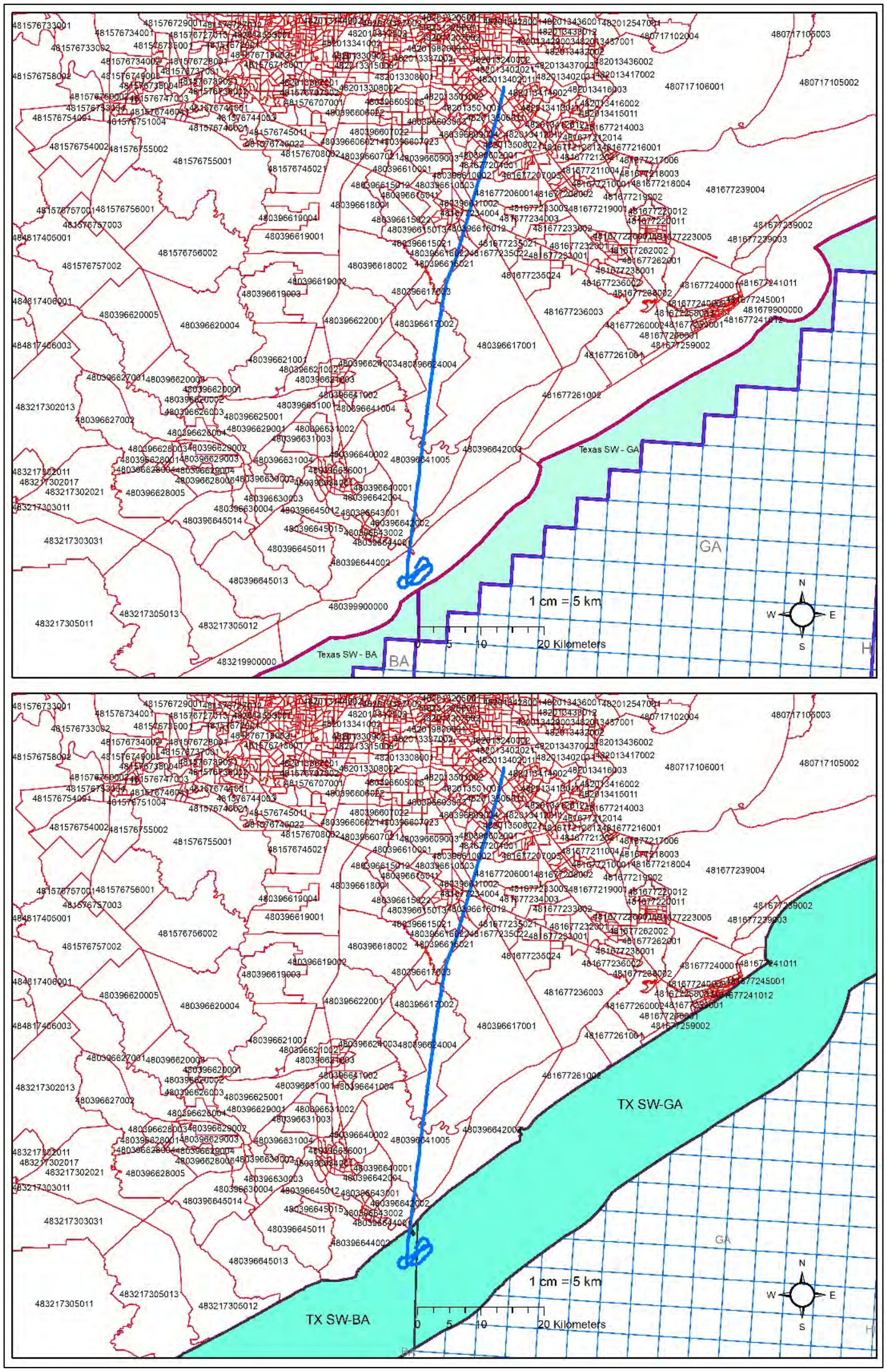


Figure A.8. Trip Classification Change after Spatial Boundary Adjustments.
Note: Example of a change in trip from onshore-to-onshore (top) to onshore-to-offshore (bottom) based on properly delineating between land, State water, and Federal water.

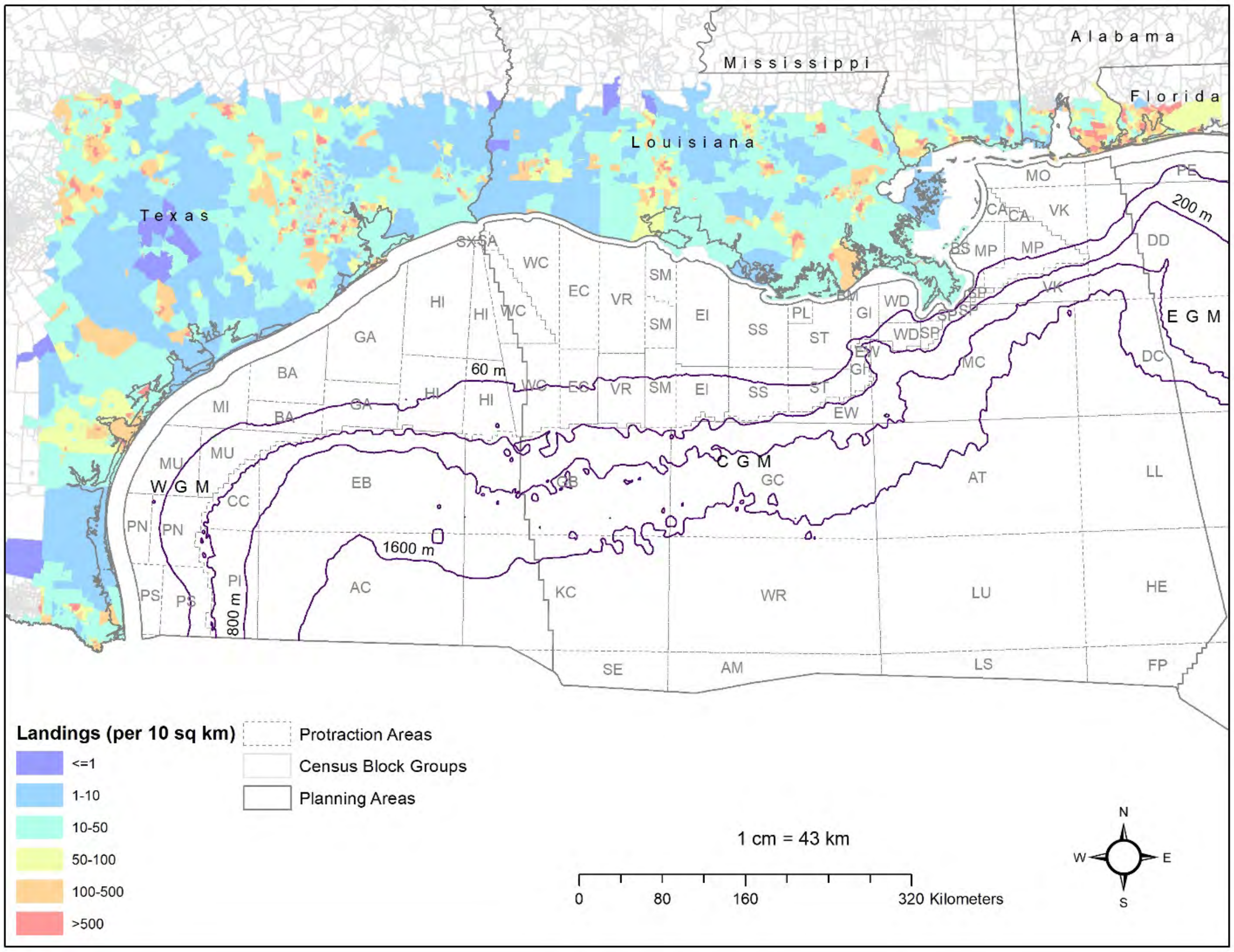


Figure A.9. Spatial Distribution of Onshore-to-Onshore Helicopter Landings.
Source: Harris 2019 and authors' computations.

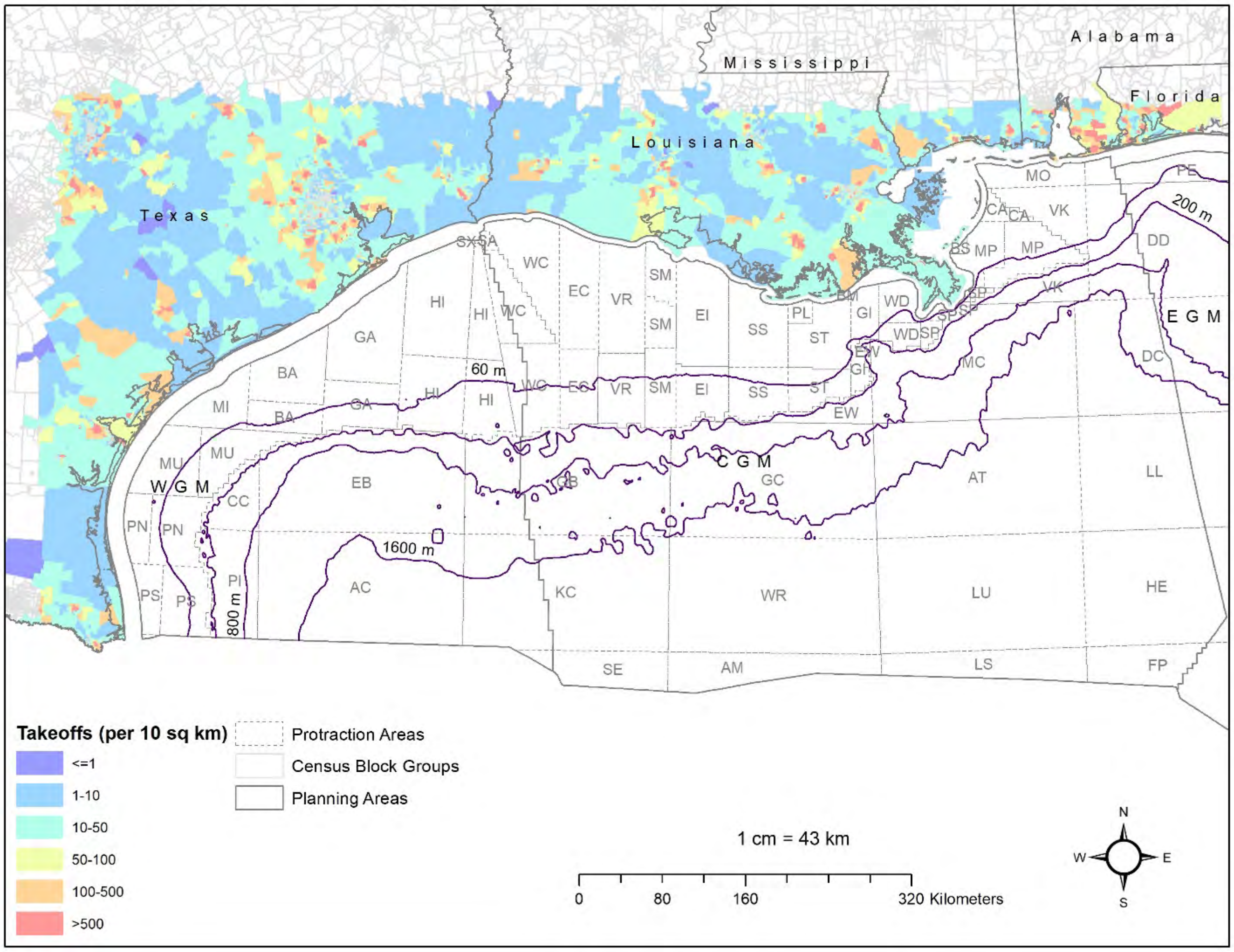


Figure A.10. Spatial Distribution of Onshore-to-Onshore Helicopter Takeoffs.
Source: Harris 2019 and authors' computations.

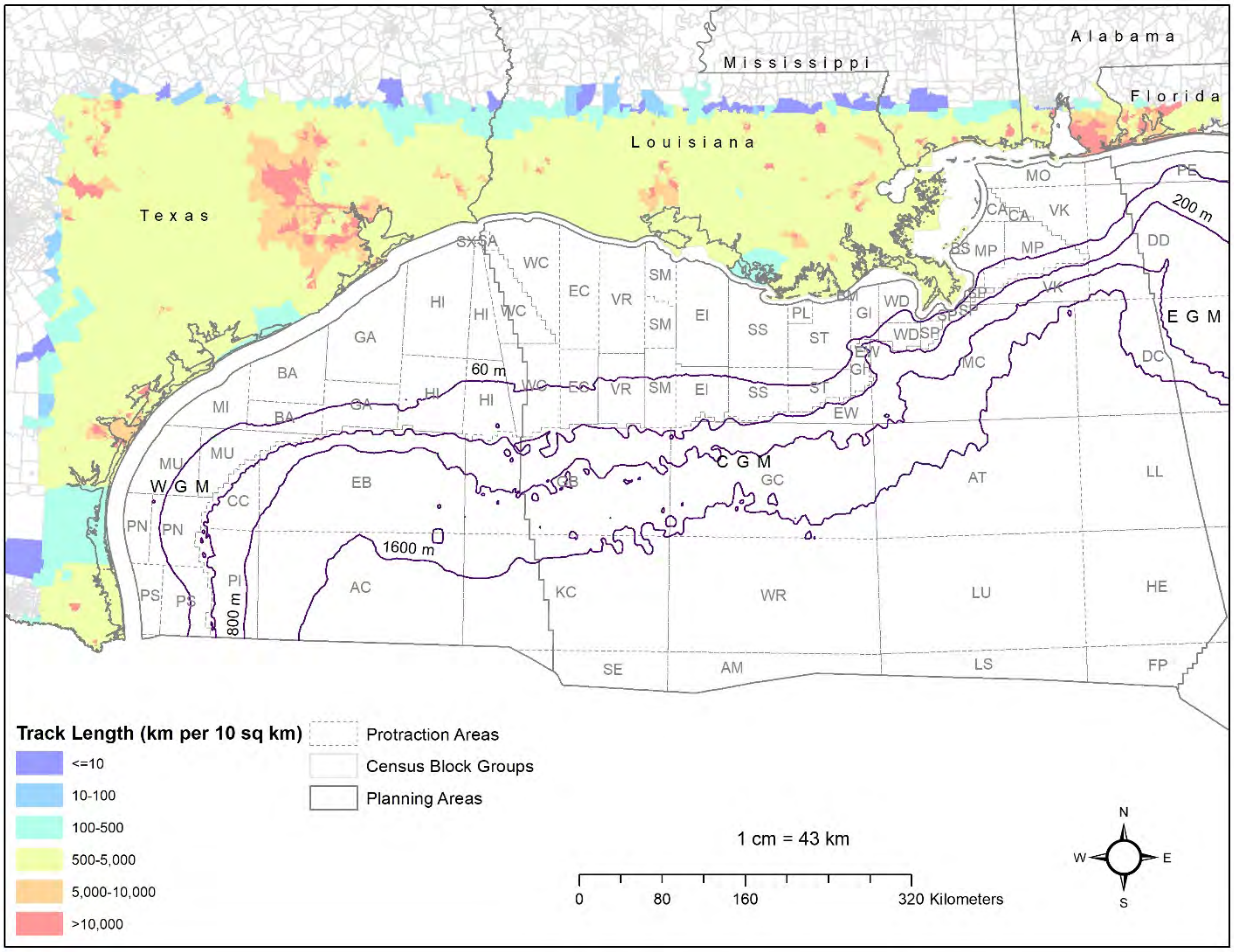


Figure A.11. Spatial Distribution of Onshore-to-Onshore Helicopter Distance Flown.
Source: Harris 2019 and authors' computations.

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The Department of the Interior Mission

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

The Bureau of Ocean Energy Management Mission

The Bureau of Ocean Energy Management (BOEM) is responsible for managing development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.