Proposed Enhancements to the Mineral Management Service Commercial Marine Vessel Emission Inventory for the Gulf of Mexico

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Abstract

The Minerals Management Service (MMS) has been developing emission inventories of the Gulf of Mexico for over 10 years. These inventories include emission estimates from oil platforms operating in the central and western portions of the Gulf as well as non-platform emission sources. For some pollutants, such as NO_x and SO_2, the non-platform emission sources account for the majority of emissions. One of the more important non-platform sources concerns commercial marine vessels (CMV). This paper reviews the procedures used to estimate CMV emissions in the 2000 MMS Gulfwide inventory and recommends the use of International Comprehensive Ocean Atmospheric Data Set (ICOADS) to more accurately adjust and allocate emissions spatially.

Introduction

The MMS is responsible for determining if air pollutant emissions from platform and non-platform sources in the Gulf of Mexico influence the ozone attainment (and nonattainment) status of onshore areas. To this end, MMS implemented the *Gulfwide Emission Inventory Study* (DOI/MMS 2004) to develop a base year 2000 inventory of criteria pollutant and greenhouse gas emission sources in the Gulf. In addition to compiling activity data from platform operators, the Gulfwide study collected activity data and calculated emissions for a number of non-platform sources including:

- Survey Vessels,
- Drilling Rigs,
- Support Vessels,
- Support Helicopters,
- Pipe Laying Operations,
- The Louisiana Offshore Oil Platform (LOOP),
- Vessel Lightering,
- Commercial/recreational Fishing,
- Military Vessel Operations,
- Commercial Marine Vessels,
- Biogenic/Geogenic Sources, and
- Platform Construction and Removal Vessels.

These non-platform sources are considered significant emission sources in the Gulf of Mexico.

Including emissions from oil platforms, non-platform emission sources accounted for approximately 64 percent of NO_x emissions and 87 percent of SO_2 emissions in the 2000 Gulfwide Inventory.

This paper will focus on proposed enhancements to the CMV emission estimates. CMVs are involved in transporting a wide range of agricultural, manufacturing, and chemical products through the Gulf. CMVs tend to be powered by either diesel engines that combust diesel or residual oil fuels or steam ships that burn residual fuel. Though some emissions may occur due to evaporative losses associated with the transportation of volatile chemical products, most of the emissions associated with CMVs are from the combustion of fuels used to propel the marine vessels or operate ancillary equipment.

In the 2000 inventory of non-platform emission sources, CMV emission estimates for diesel-powered vessels were estimated by using ton-mileage emission factors developed from EPA data (EPA/EFIG 2003) and ship lane activity data for Federal waters in the western and central areas of the Gulf of Mexico obtained from the Army Corps of Engineers (ACE). Steamship emission estimates were extrapolated from the EPA's National Emission Inventory (NEI) (EPA/EFIG 2003).

A similar study developed for the MMS in 1995 (DOI/MMS 2003) seems to have included all CMV activity for all waters of the Gulf of Mexico, including those occurring in state waters. In order to compare the two inventories, the methodology used in the 2000 inventory for the Western and Central areas of the Gulf were also applied to State waters and to the Eastern Gulf area. Table 1 shows this comparison of the 1995 inventory data with 2000 estimates.

Table 1. Comparison of Emissions for Commercial Marine Vessels Operating in the Gulf of Mexico

	Pollutant (tons per year)		
Study	**NO_x**	**VOC**	**CO**
2000 MMS Inventory			
MMS area (Western & Central Gulf)	20,592	181	2,029
MMS (Eastern Gulf)	16,488	144	1,625
State waters	33,961	298	3,347
Gulf Total	**71,041**	**623**	**7,001**
1995 MMS Inventory			
Gulf Total	**85,961**	**3,745**	**9,563**
Percent Difference	-17	-83	-27

A majority of the difference between these two inventories is accounted for due to the different emission factors used in the 1995 and 2000 studies. For example, the emission factors used in the 2000 inventory were obtained from EPA regulatory background documents in support of the EPA' recent marine vessel rule making (EPA/OTAQ 2000). These emission factors are approximately 14 percent less for NO_x, 83 percent less for VOC, and 23 percent less for CO, relative to the older AP-42 emission factors used in the 1995 study (EPA/EFIG 1989). The remaining difference is assumed to be related to variations in ship traffic activity.

Discussion - Potential Enhancements for the CMV approach

For the 2005 MMS inventory, a new approach is being considered that relies on data from the National Oceanic and Atmospheric Administration's National Climate Data Center. The National Climate Data Center manages the ICOADS. The ICOADS data record weather observations from ships at sea and also include ship positioning data at the time that weather observations were made. The database tracks observations back to 1784 and is now updated annually. The vessel observation information can be used to evaluate spatial vessel traffic information. For the 2005 MMS Gulf inventory, it is proposed that ship traffic patterns be derived from the ICOADS, Standard 1a, release 2.0. Developing traffic profiles from these data relies on three assumptions:

- First, ship location data summarized in ICOADS represents information from commercial ships generated routinely and at equal intervals. This allows for the assumption that a linear relationship exists between ship observations and traffic density. On an annual basis, 2002 ICOADS data revealed that ships reported observations an average of 97 times, although monthly average observations are lower.

- Second, the sample of commercial vessels reporting to ICOADS is representative of the commercial fleet voyage patterns. 966,194 observations were reported by ships in 2002 to ICOADS. Among these observations, 29,968 (3.1 percent of total) were reported by unidentified vessels. 9,669 ships, 22 percent of the world cargo ship fleet (43,852 cargo ships) in 2002, made most (936,232) of the observations. Monthly summary statistics are provided in Table 2, shown below.

- Third, specific characteristics of vessels in any regional location are representative of overall fleet characteristics. However, we know that trade patterns are not uniform. For example, tanker traffic serving Delaware Bay primarily brings cargo from southern routes (e.g., South America, Africa, and/or the Far East). This assumption will be studied in greater detail in the next section of this report.

Table 2 . Summary Analysis of Global ICOADS Data for 2002

Ship Observations Summary 2002													
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Annual**
Total observations	78,019	72,887	78,384	76,413	81,663	79,002	84,848	84,778	80,833	86,421	84,030	78,916	966,194
Identified ships	74,375	69,629	75,019	73,092	77,639	75,300	82,559	83,122	79,421	85,067	82,739	78,270	936,232
Unidentified ships	3,644	3,258	3,365	3,321	4,024	3,702	2,289	1,656	1,412	1,354	1,291	646	29,962
Unidentified. % of total	4.7	4.5	4.3	4.3	4.9	4.7	2.7	2.0	1.7	1.6	1.5	0.8	3.1
Unique ships	2,770	2,691	2,855	2,868	3,049	2,998	3,208	2,264	2,252	2,263	2,240	2,175	9,669
Observations/ship	27	26	26	25	25	25	26	37	35	38	37	36	97

Given these assumptions and observations, the ICOADS data are especially useful in identifying the ship routes that vessels actually take. What is particularly interesting is that in some notable cases the ICOADS ship routes do not match the shipping lanes documented by the ACE.

When all of the ICOADS data are reviewed for the Gulf of Mexico, the traffic pattern seems to be random, but mostly within the general area of the ACE shipping lanes as noted in Figure 1. The traffic pattern becomes more interesting if you disaggregate the data by ship type. Figure 2. Shows the spatial distribution of vessels where cargo is transported by trucks that can be rolled on and rolled off of the ship (roll on / roll off); even though the data are relatively sparce, a limited number of shipping lanes are apparent. What is particularly interesting is that the vessels traveling around the Florida Keys toward Houston do not use ACE shipping lanes. A similar pattern is noted when looking at the routes that ocean-going tugs travel in the Gulf of Mexico (Figure 3.). Though the data are limited, the vessels seem to travel along a singular route that runs between two ACE shipping lanes.

Bulk carriers (Figure 4.), cruise ships (Figure 5.), and general cargo vessels (Figure 6.) are interesting as they do tend to travel along ACE shipping lanes, except for the route between the Florida Keys and Houston. For general cargo operations, the vessel fairways are less distinct than some of the other vessel categories. As these vessels are not limited to specific ports and can drop off or pick up cargo at almost any port facility, it is not surprising that their ship fairways appear more dispersed.

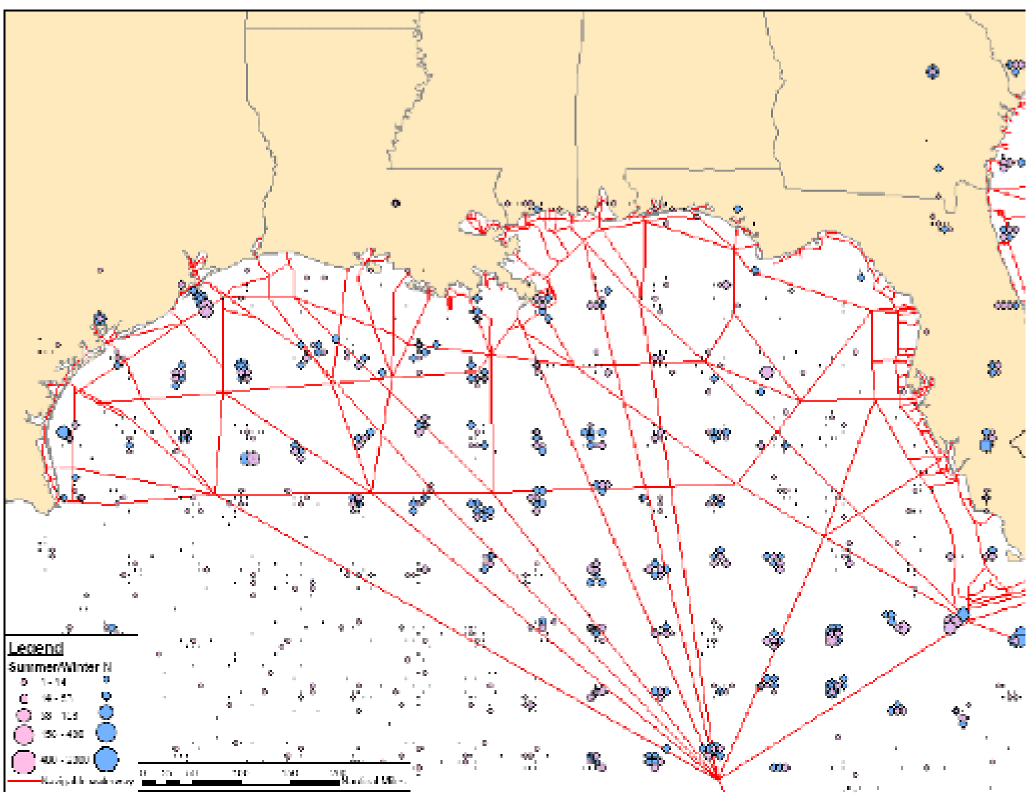


Figure 1. Aggregated ICOADS data.

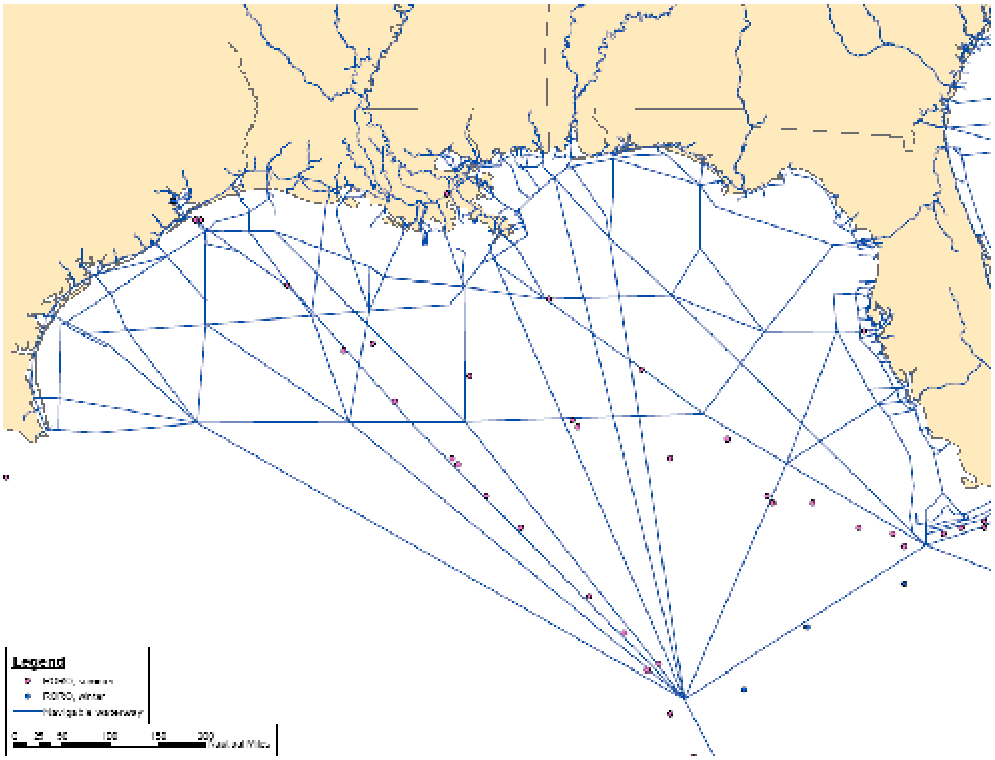


Figure 2. Spatial distribution of Roll on /Roll off Vessels

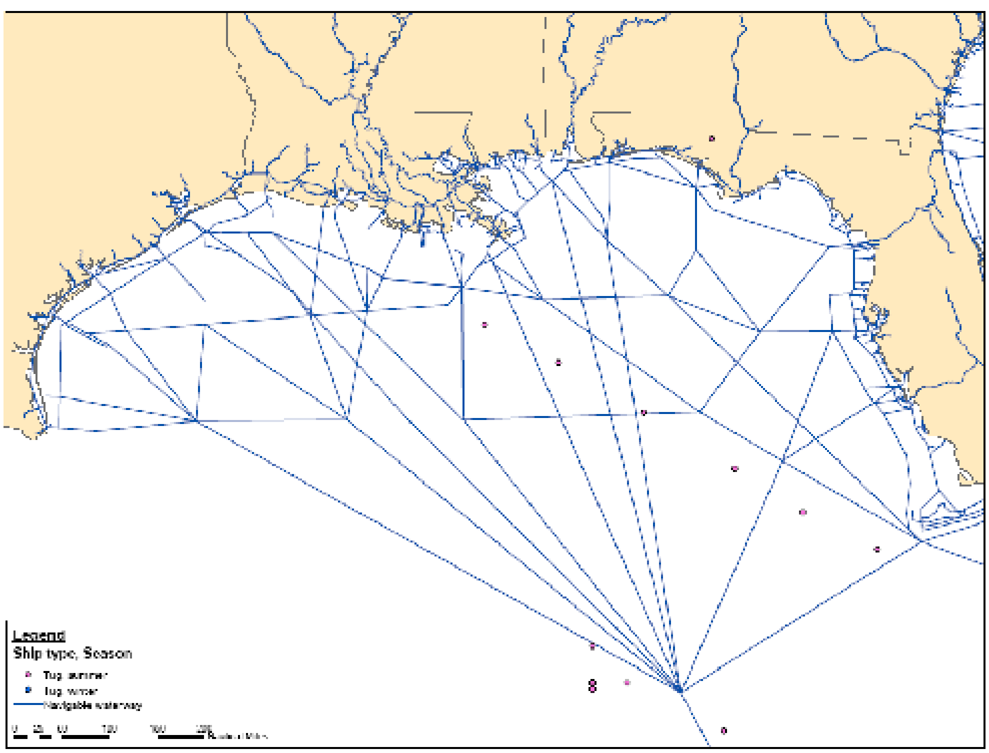
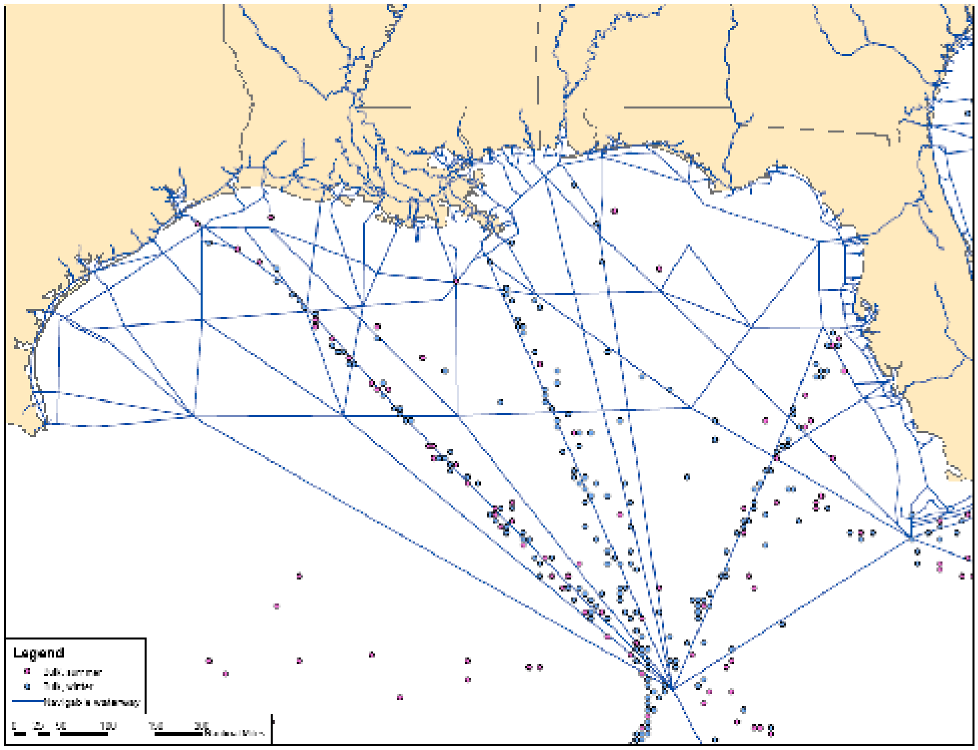


Figure 3. Spatial Distribution of Ocean-Going Tugs Operations



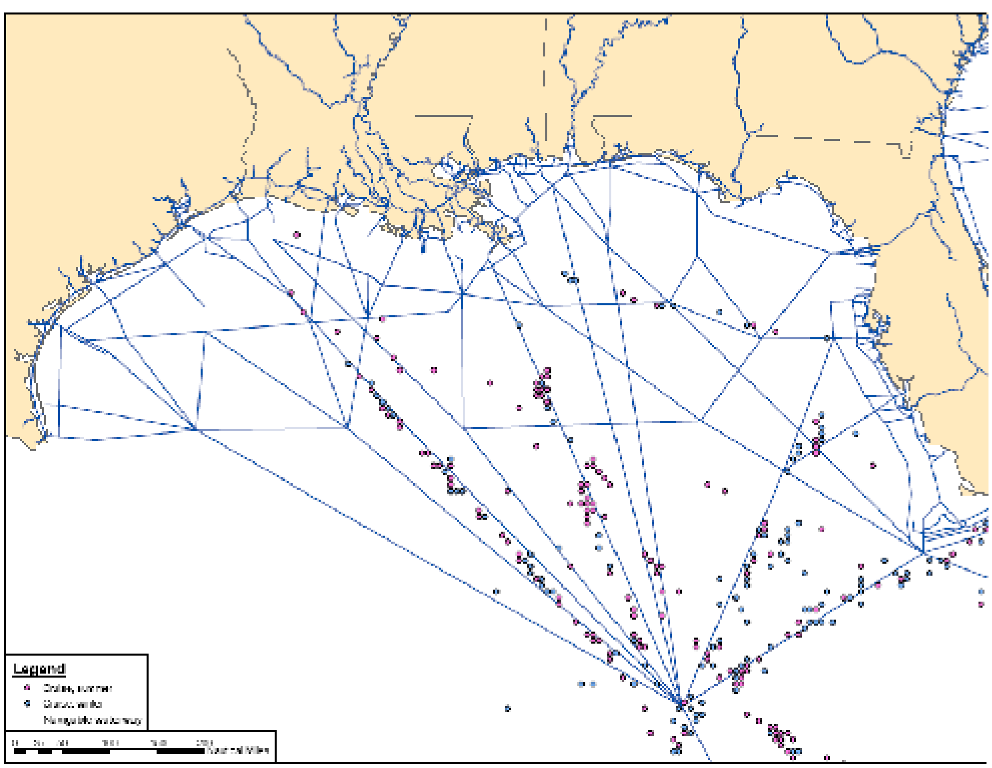


Figure 4. Spatial Distribution of Bulk Carrier Operations in the Gulf of Mexico

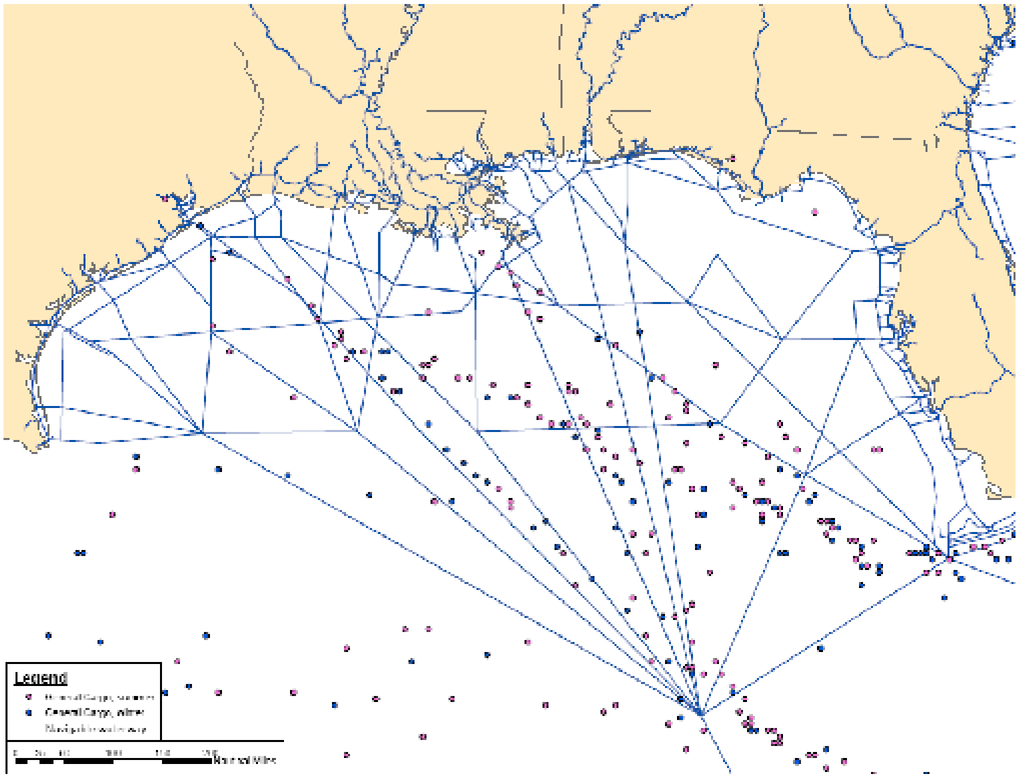
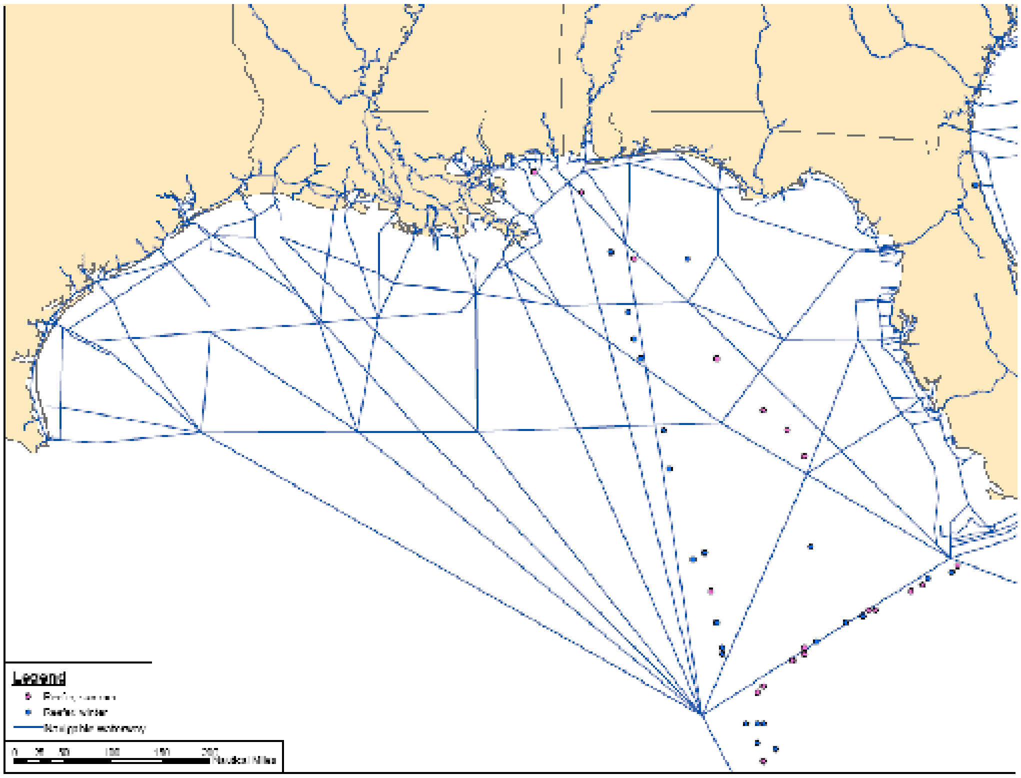


Figure 5. Spatial Distribution of Cruise Vessel Operations in the Gulf of Mexico

Figure 6. Spatial Distribution of General Cargo Vessel Operations in the Gulf of Mexico

This is contrasted with refrigeration vessels that transport fruits and vegetables (Figure 7.) from South American ports. These refrigeration vessels can only visit ports with large refrigeration storage warehouses such as those found at the port of Pascagoula, Mississippi. Tanker traffic (See Figure 8.) also seems to be directed toward specific ports in the Gulf of Mexico such as Houston, the Louisiana Offshore Oil Port (LOOP) or U.S. Coast Guard monitored lightering zones south of Houston. Probably one of the most significant ship traffic routes concerns containerized vessels as noted in Figure 9. Again, a very defined ship traffic pattern is apparent, with most of the vessels transiting from the Florida Keys to Houston.

Conclusions



As is apparent from the graphic representation of the ICOADS data for the Gulf of Mexico, this data set can be a useful tool to estimate spatial distribution of vessel activity. Figure 10 shows how the 2000 emissions were spatially allocated to individual links of the ACE shipping lanes. Assuming activity is a surrogate for emissions, the ICOADS data would provide a more dispersed spatial allocation as is noted in Figure 11. The difference between the two spatial allocation methods may be particularly important as the data are used for modeling purposes and the ACE data assign emissions fairly close to shore, while the ICOADS data will put most of the emissions significantly further out to sea.

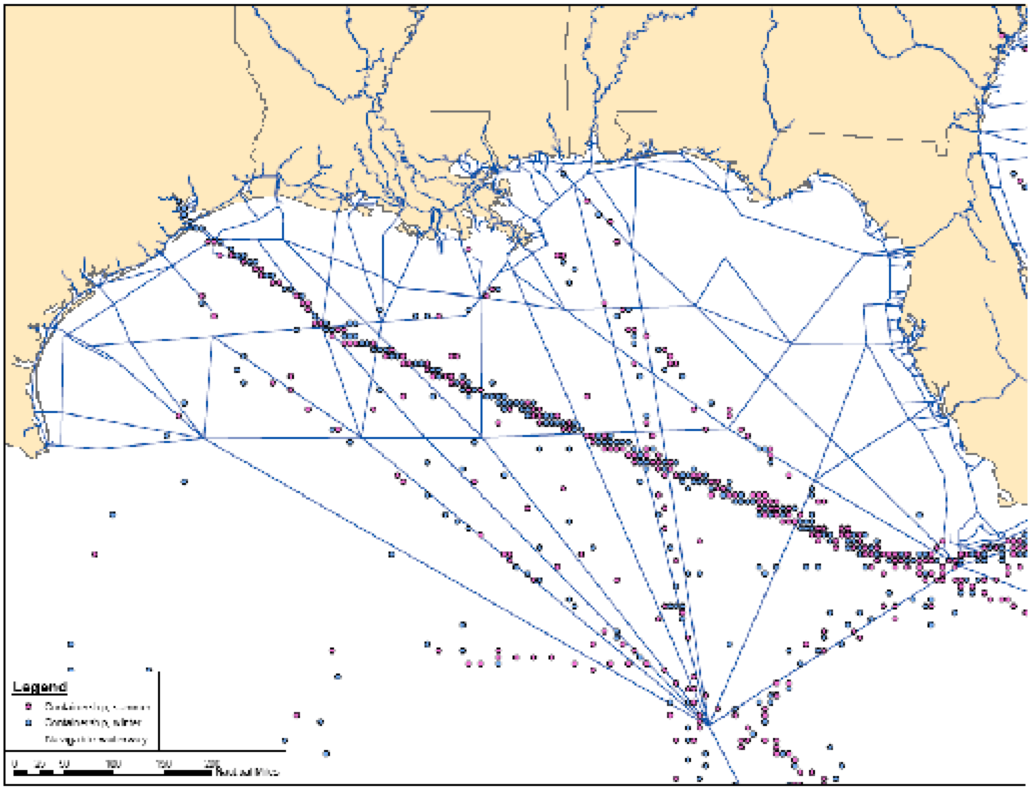


Figure 7. Spatial Distribution of Refrigeration Vessel Operations in the Gulf of Mexico

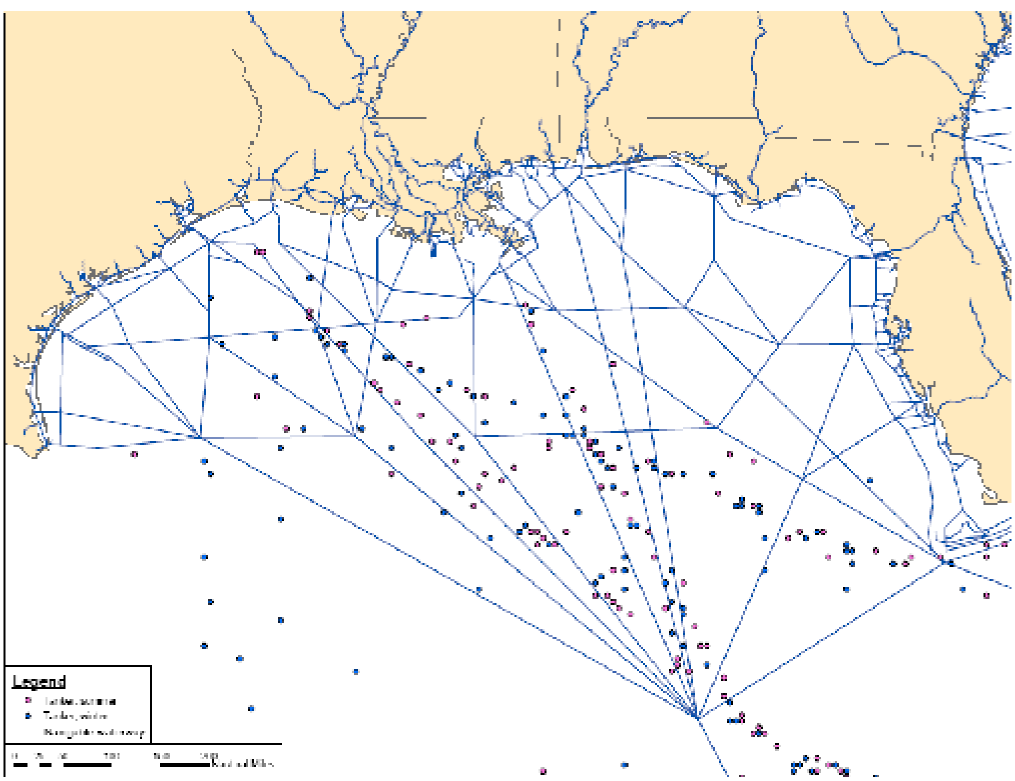


Figure 8. Spatial Distribution of Tanker Operations in the Gulf of Mexico

Figure 9. Spatial Distribution of Containerized Vessel Operations in the Gulf of Mexico

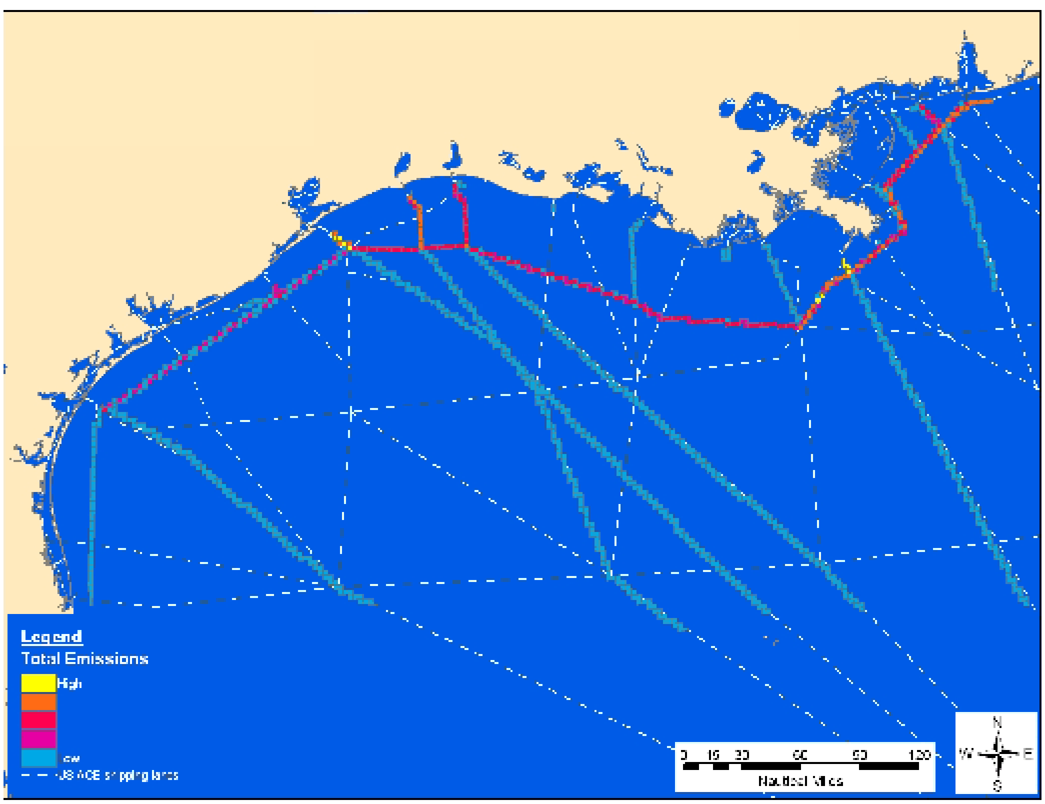


Figure 10.

MMS 2002 CMV Emission Estimates by Army Corps of Engineers Shipping Lane

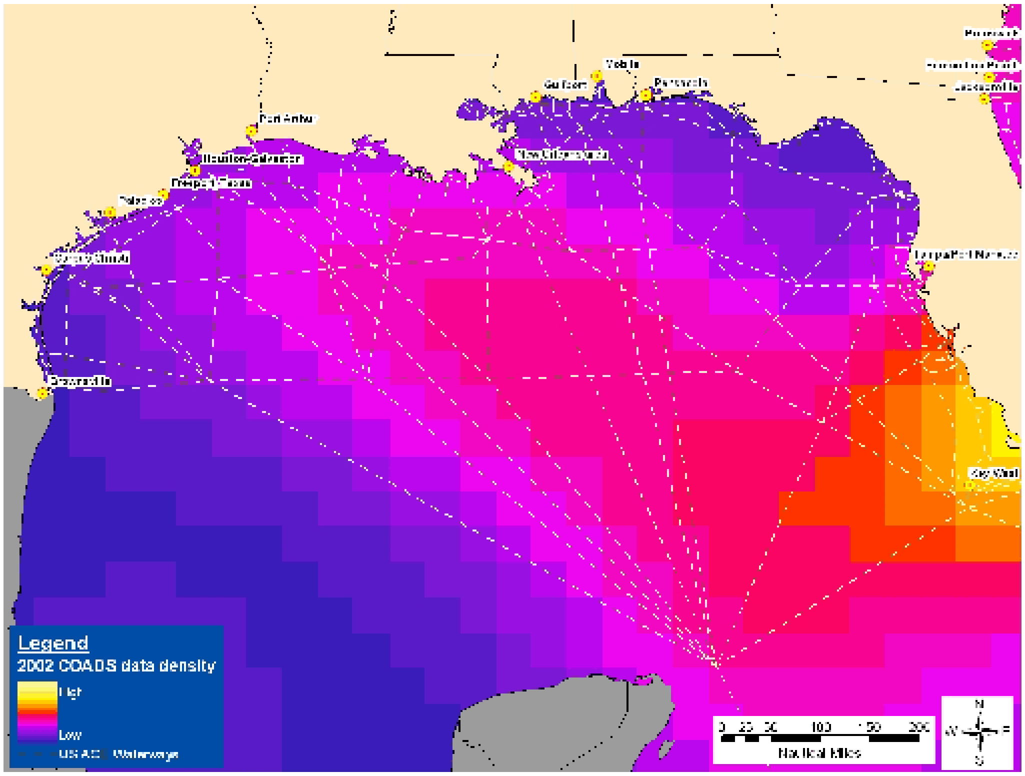


Figure 11. ICOADS CMV Aggregated Activity for the Gulf of Mexico

Using ICOADS data can also be important in assigning the correct emission factors to vessels. Variations in vessel characteristics and operations between vessel types can be very significant, and the emission factors used in an inventory such as MMS' Gulfwide inventories, should account for these difference in order to provide the most accurate emission estimates. Table 3 summarizes some vessel characteristics for CMVs operating in US waters. This table shows that average deadweight tonnage can vary by two orders of magnitude from the small ocean-going tugs to large tankers. Furthermore vessel speed can vary from the slower tugs, bulk, general cargo and tanker vessels to vessels such as containerships, cruise ships and ferries that are up to 70 percent faster. These faster vessels have significantly higher total power ratings. A tugs total power can be up to an order of magnitude different from that of a cruise ship. Given these significant differences it is important to attribute the most appropriate emission factor to each vessel type.

ERG is currently recommending the use of the ICOADS data for the 2005 MMS inventory, MMS is considering use of these data, but has yet to make a final determination.

Table 3. Average Characteristics by Vessel Type

Type	DeadWeight (tons)	Maximum Speed (knots/hr)	Total Vessel Power[a] (kW)
Bulk	47,869	14	7,840
Containership	41,867	22	25,539
Cruise	5,559	20	28,236
Ferry	3,482	20	8,706
General Cargo	16,258	14	5,396
Reefer	8,554	18	7,444
RORO	14,746	16	9,012
Tanker	60,811	15	9,670
Tug	746	13	2,912

[a] Note that total power includes propulsion and ancillary engines

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