Emissions Trends Analysis

Bebhinn Do
Eastern Research Group, Inc.

BOEM Contract No. M13PC00005
BOEM COR: Holli Ensz
Project Manager: Darcy Wilson
Eastern Research Group, Inc.

BOEM
Bureau of Ocean Energy Management

ERG

Objectives

- To conduct an Emissions Trends Analysis, looking at detailed comparisons and deviations of all Gulf of Mexico OCS region 2000, 2005, 2008, 2011, and 2014 emissions data

- Guiding questions:
  - Can we explain the changes in emissions from inventory to inventory?
  - Is there an overall trend to emissions?
  - Can we use this information to develop a predictive model to help with planning?

BOEM Bureau of Ocean Energy Management

ERG

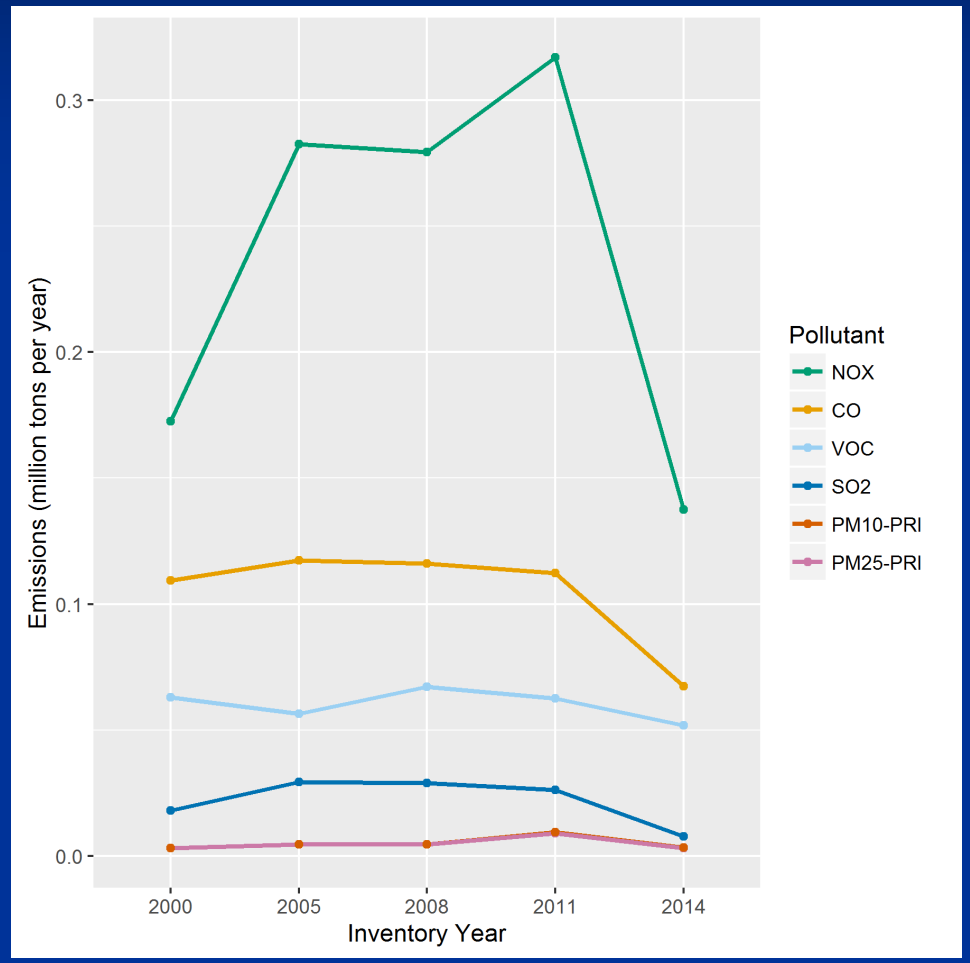
Trend Analysis - Approach

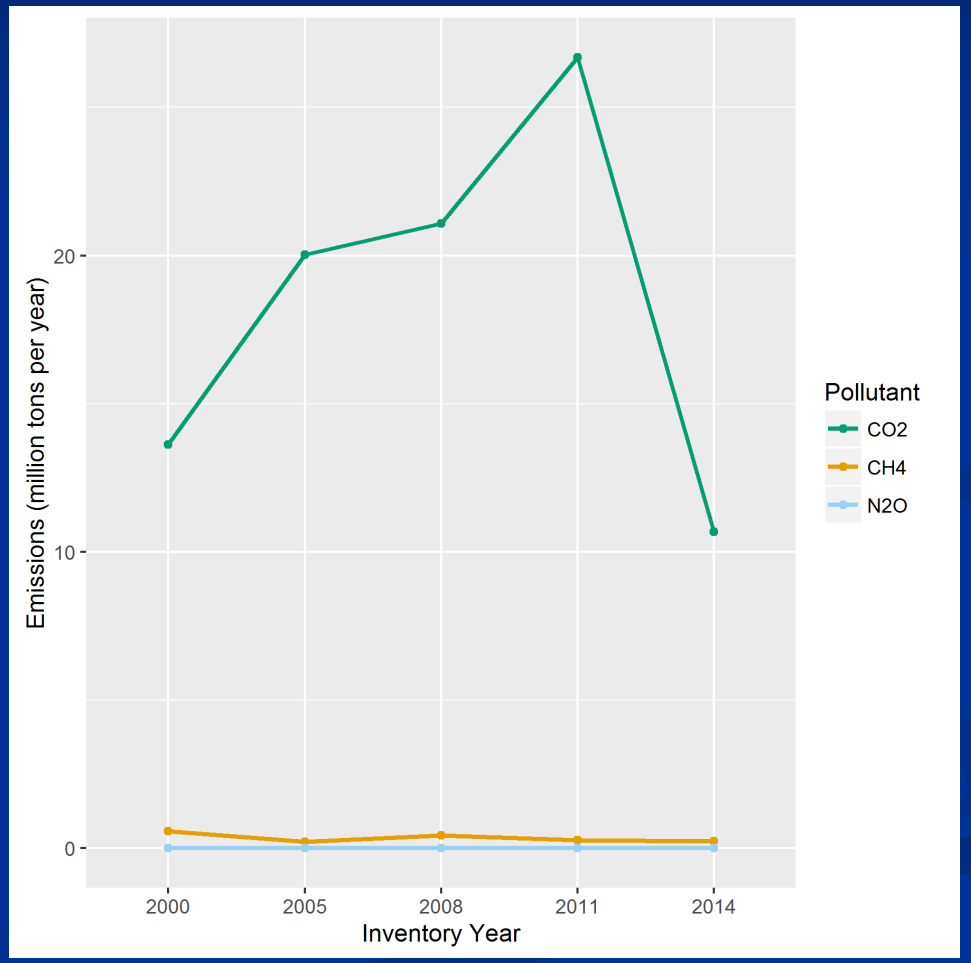
- Top down approach
  - Phase 1: Trends in total emissions
  - Phase 2: Individual components
    - Platform
      - Spatial trends
      - By Type: Combustion, non-combustion, vent/flares
      - Equipment type
    - Non-Platform
      - By Type: Oil and gas vs non-oil and gas
      - Spatial trends
      - By vessel type

BOEM Bureau of Ocean Energy Management

ERG

Trends Analysis – Total Emissions

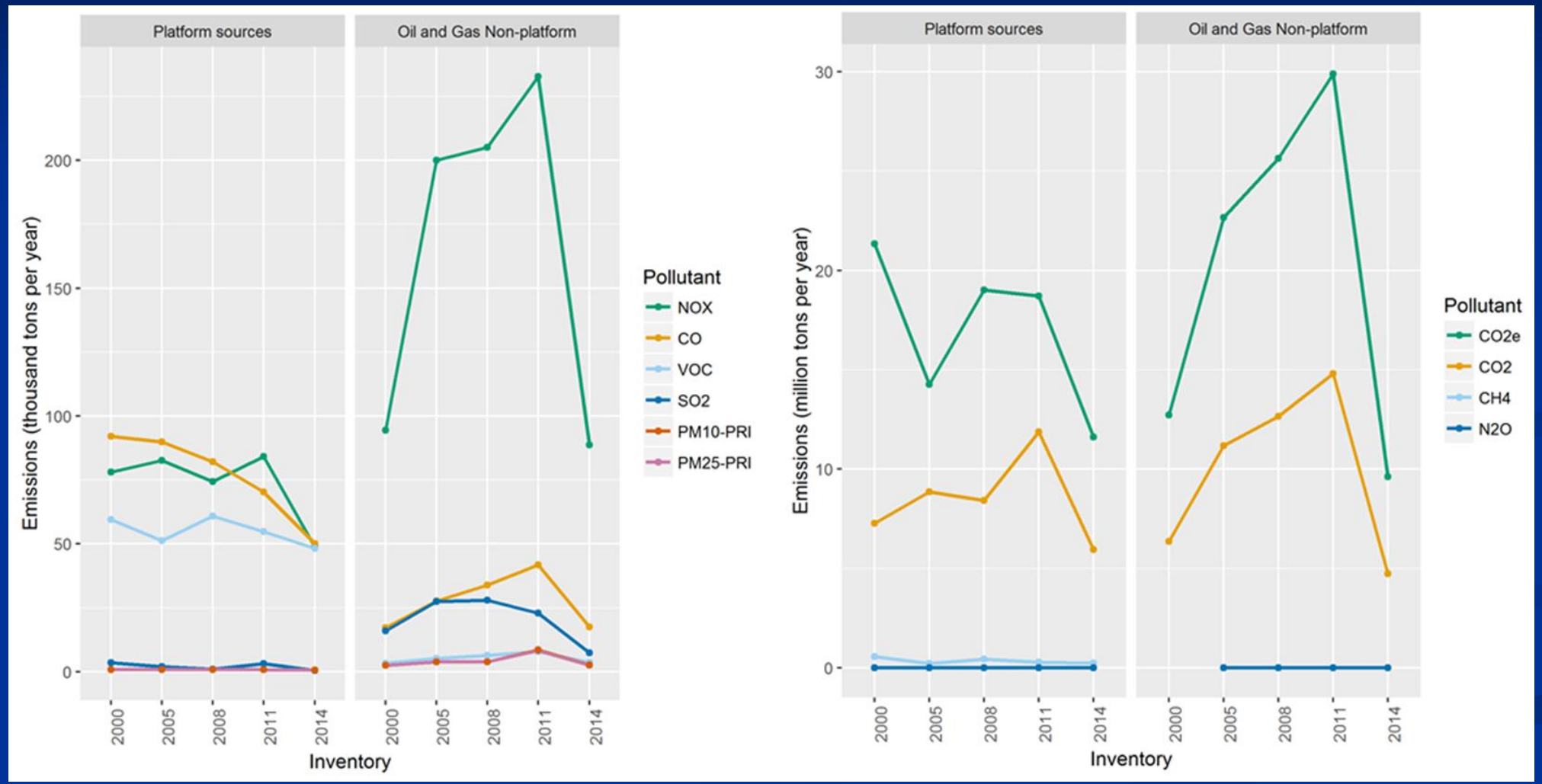




BOEM Bureau of Ocean Energy Management

ERG

Trends Analysis – Platform/Non-platform

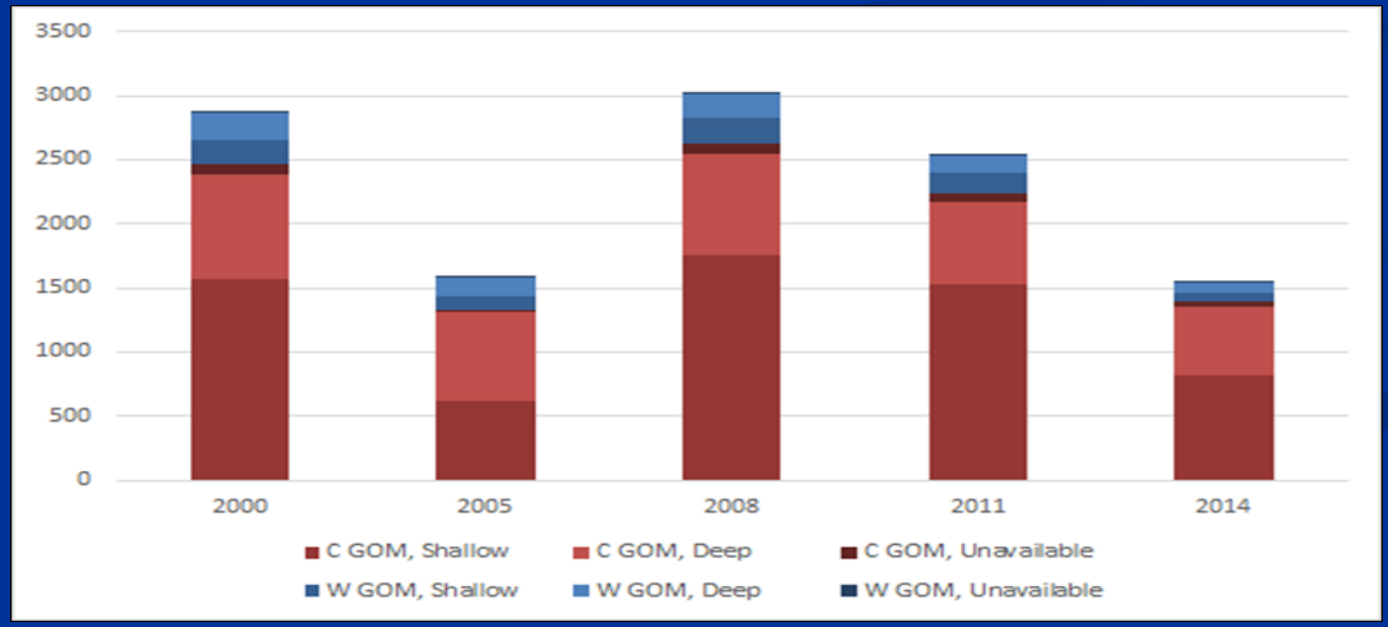


BOEM
Bureau of Ocean Energy Management

ERG

Platforms - Spatial Trends

- The majority of active platforms in the Central/Eastern GOM
- Approximately 60% of Central/Eastern GOM platforms are in shallow water
- There has been an expansion into deeper water from 2000 to 2014
- There has been a decline in shallow water platforms in the western GOM from 2000 to 2014



BOEM
Bureau of Ocean Energy Management

Platform Trends – Changes in Sources

- Platform sources included specific types of minor sources after 2005
  - Minor sources were required to report for 2014
  - When equipment records were not provided, minor source emissions were carried forward from 2011
- Loading operations were not included in the 2008 and 2011 Gulfwide inventories

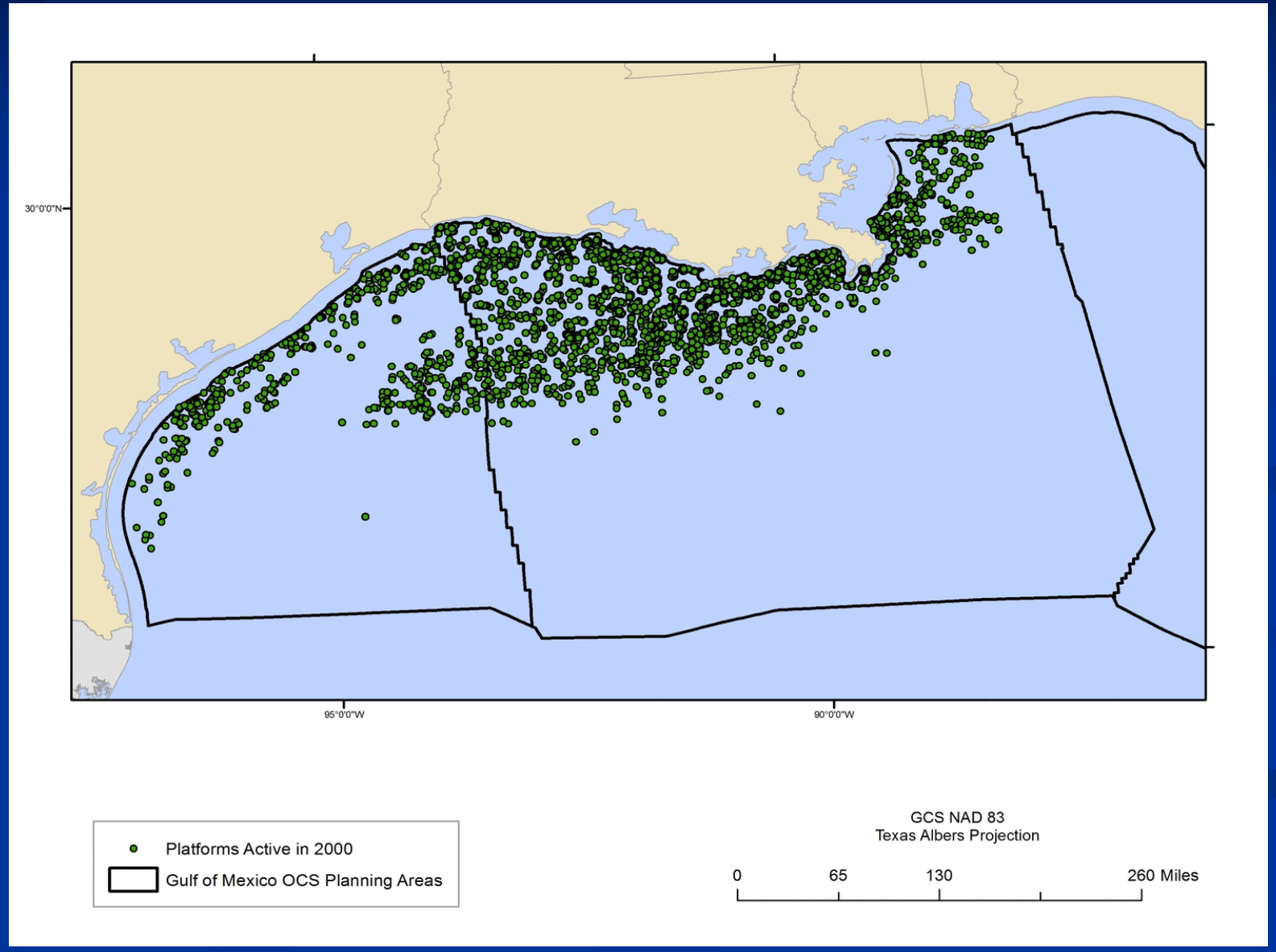
Platform equipment types included in the Gulfwide inventories

Platform Equipment Type	2000	2005	2008	2011	2014
Amine Units (AMI)	✓	✓	✓	✓	✓
Boilers (BOI)	✓	✓	✓	✓	✓
Caissons (CAI) [Minor Source]	X	X	✓	✓	✓
Diesel Engines (DIE)	✓	✓	✓	✓	✓
Drill Rigs (DRI)	✓	✓	✓	✓	✓
Combustion Flares (FLA)	✓	✓	✓	✓	✓
Fugitives (FUG)	✓	✓	✓	✓	✓
Glycol dehydrators (GLY)	✓	✓	✓	✓	✓
Loading (LOA)	✓	✓	X	X	✓
Losses (LOS)	✓	✓	✓	✓	✓
Living Quarters (LQU) [Minor Source]	X	X	✓	✓	✓
Mud Degassing (MUD)	✓	✓	✓	✓	✓
Natural Gas Engines (NGE)	✓	✓	✓	✓	✓
Natural Gas Turbines (NGT)	✓	✓	✓	✓	✓
Other (OTH) [Minor Source]	X	X	✓	✓	✓
Pneumatic Devices (PNE)	✓	✓	✓	✓	✓
Pressure/level Controllers (PRE)	✓	✓	✓	✓	✓
Storage Tanks (STO)	✓	✓	✓	✓	✓
Cold Vents (VEN)	✓	✓	✓	✓	✓
Wellhead Protectors (WHP) [Minor Source]	X	X	✓	✓	✓

BOEM Bureau of Ocean Energy Management

ERG

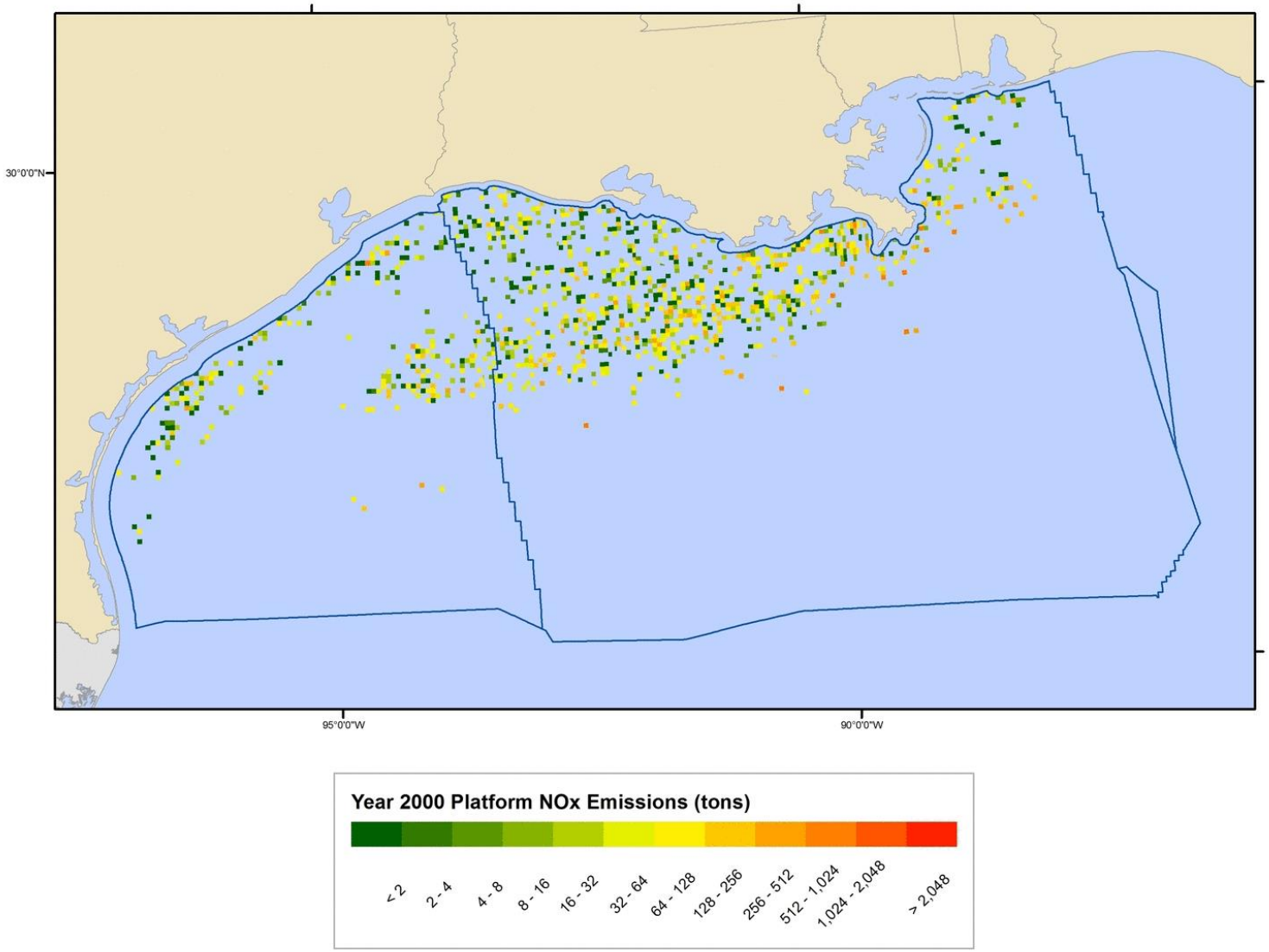
Platform Spatial Trends - Active Platform Locations



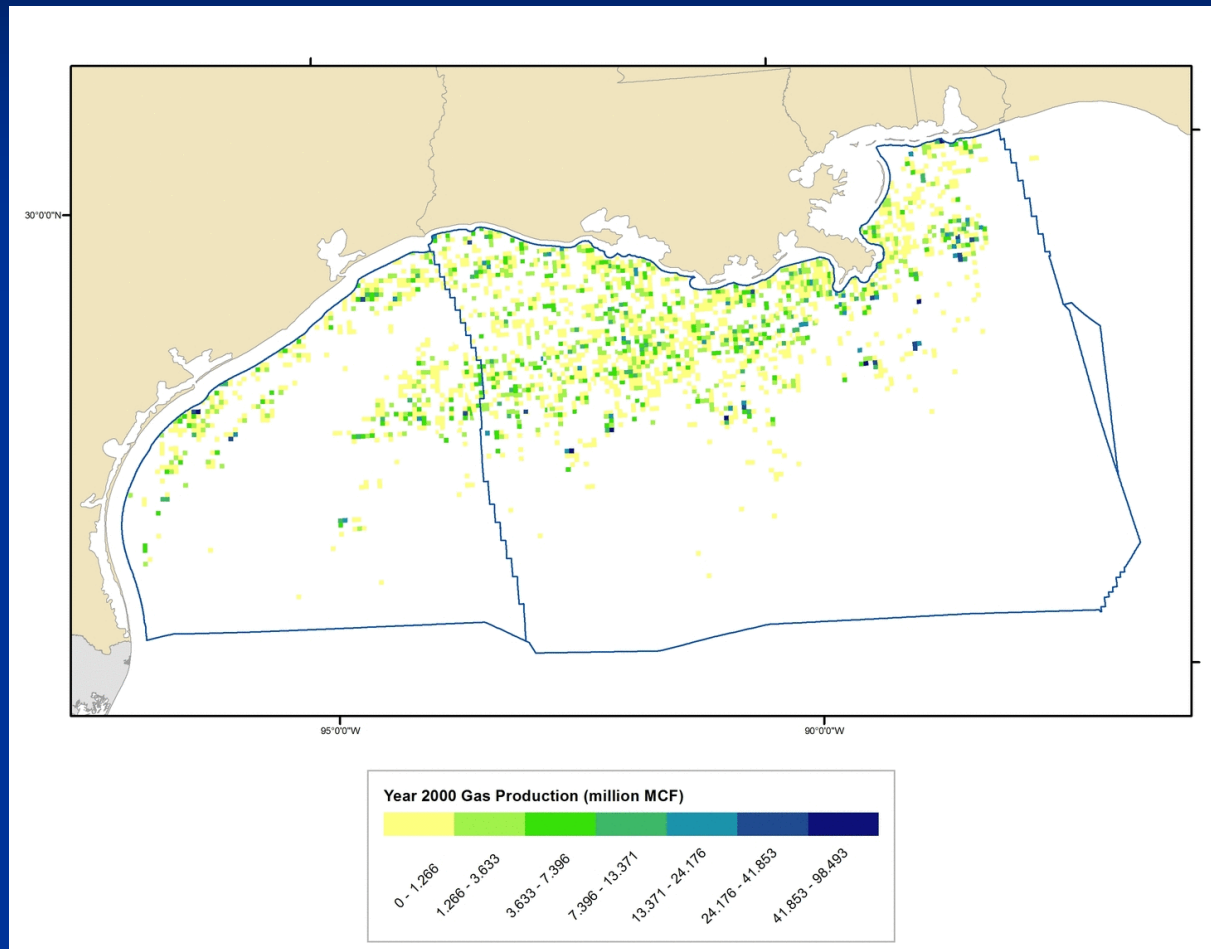
BOEM
Bureau of Ocean Energy Management

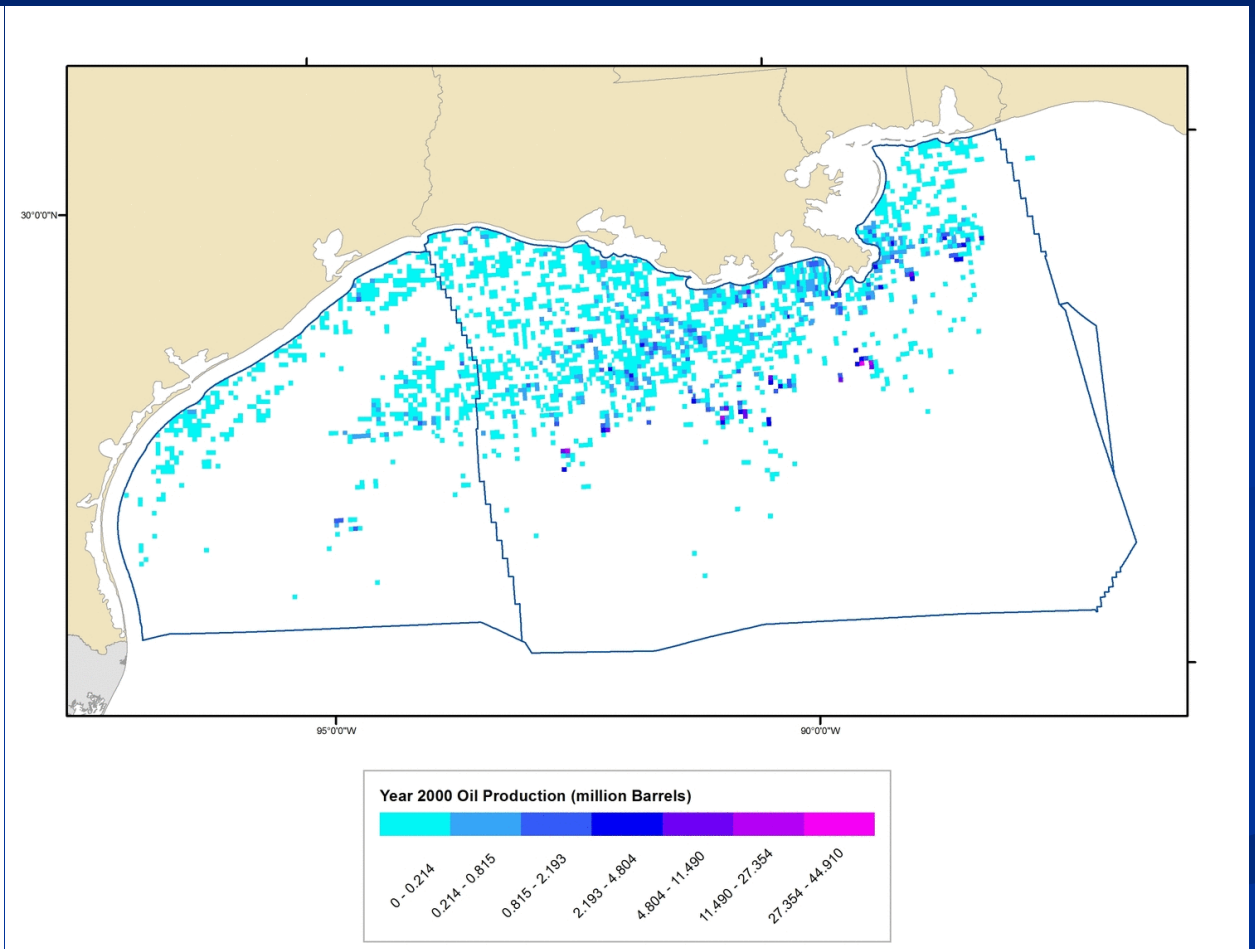
Platform Spatial Trends - Total Platform NO_x

- Emissions tend to be higher for the newer platforms in deeper waters, as shown in the spatial progression of total platform NO_x emissions



Spatial Trends - Production



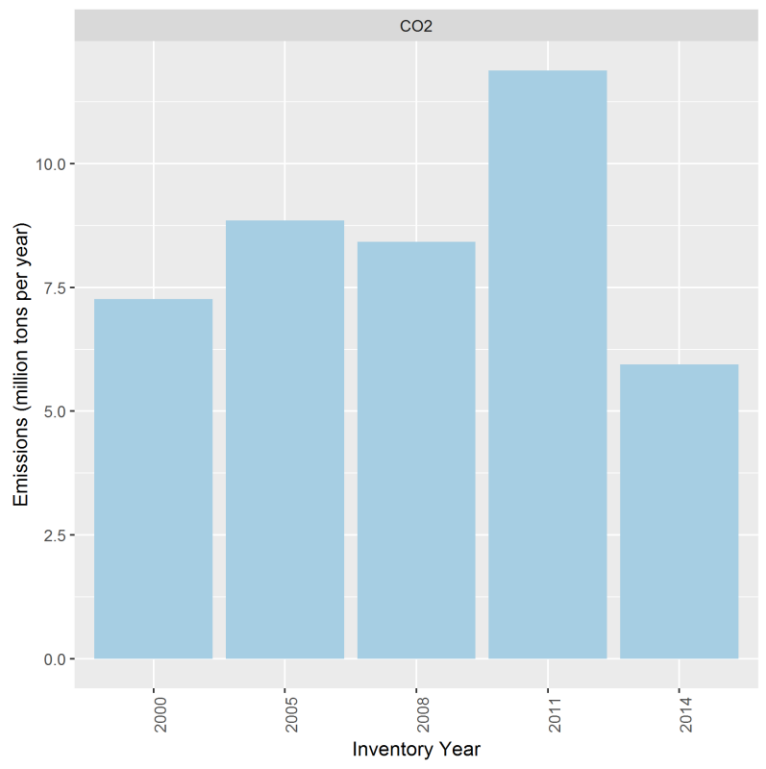


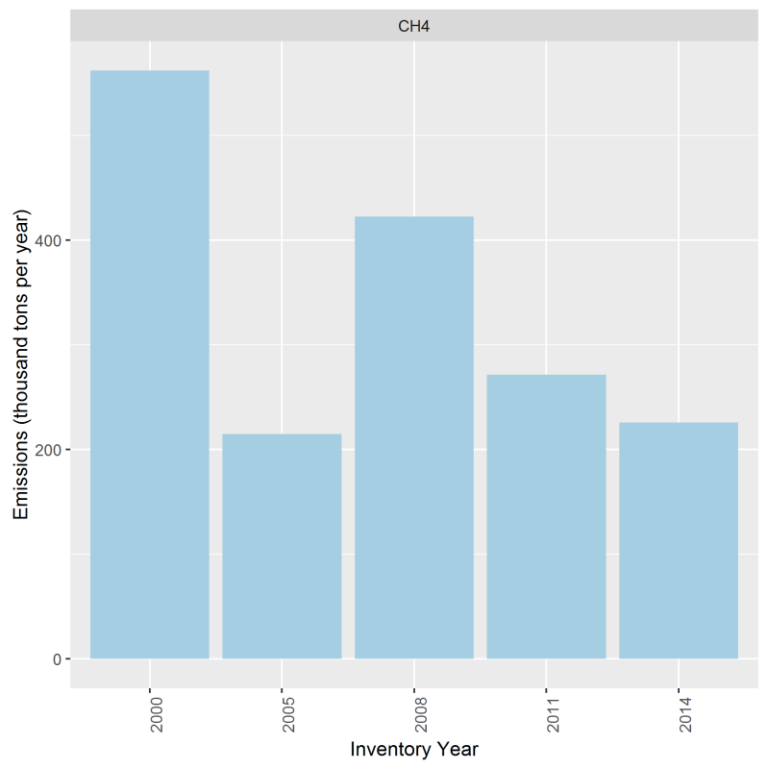
BOEM Bureau of Ocean Energy Management

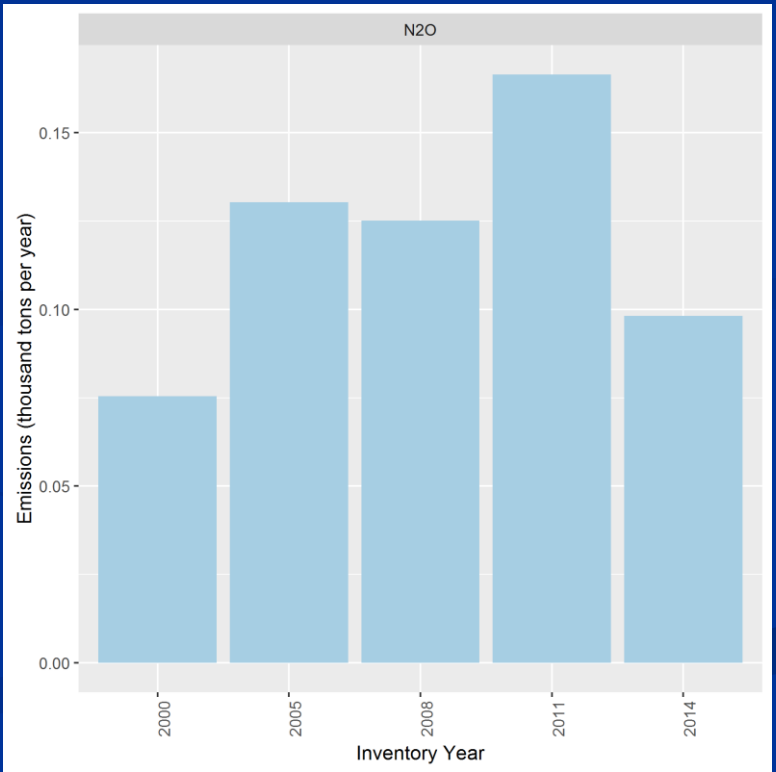
ERG

Platform Trends - GHG Emissions

- CO_2 emissions make up the largest portion of the inventories
- GHGs have high variability in their values



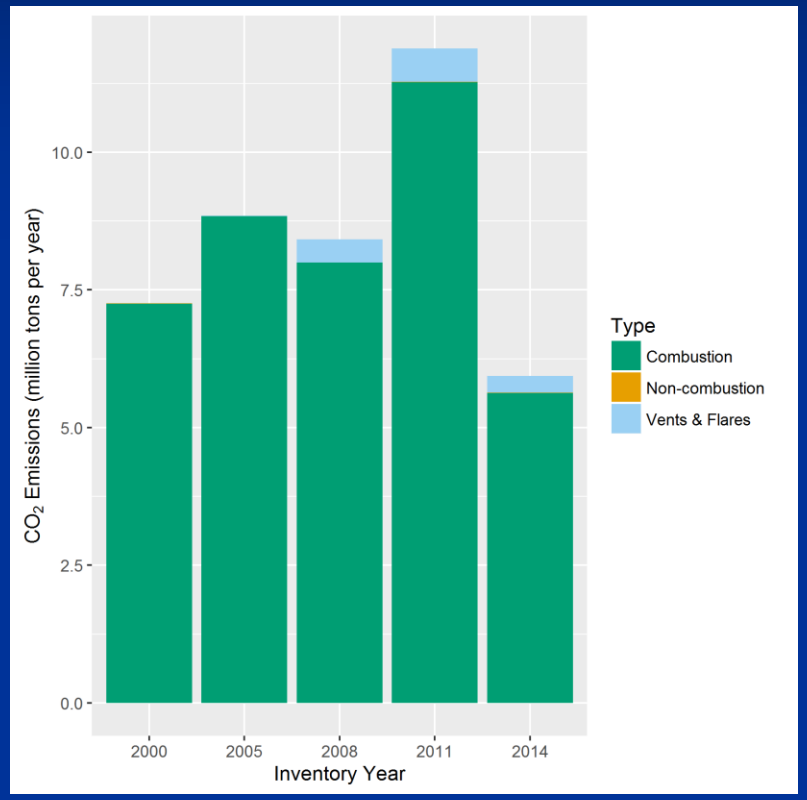


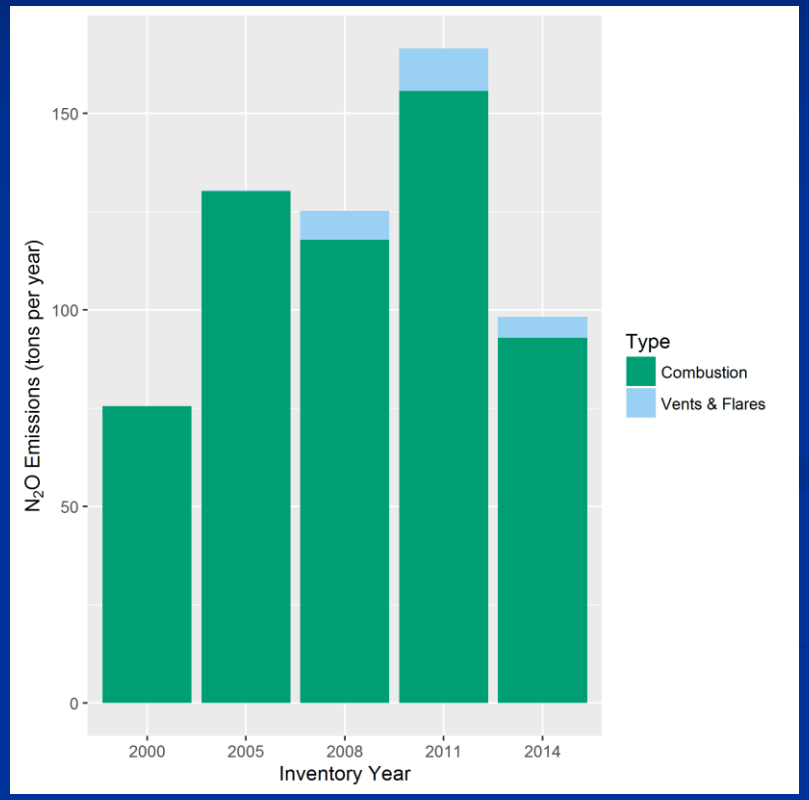


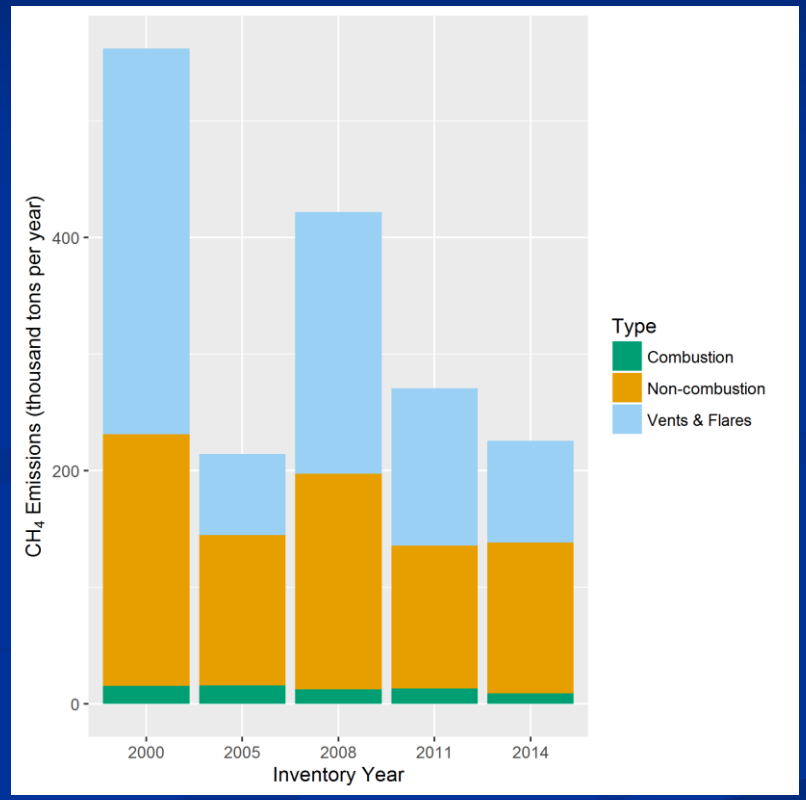
BOEM Bureau of Ocean Energy Management

ERG

Platform Sources – by Type





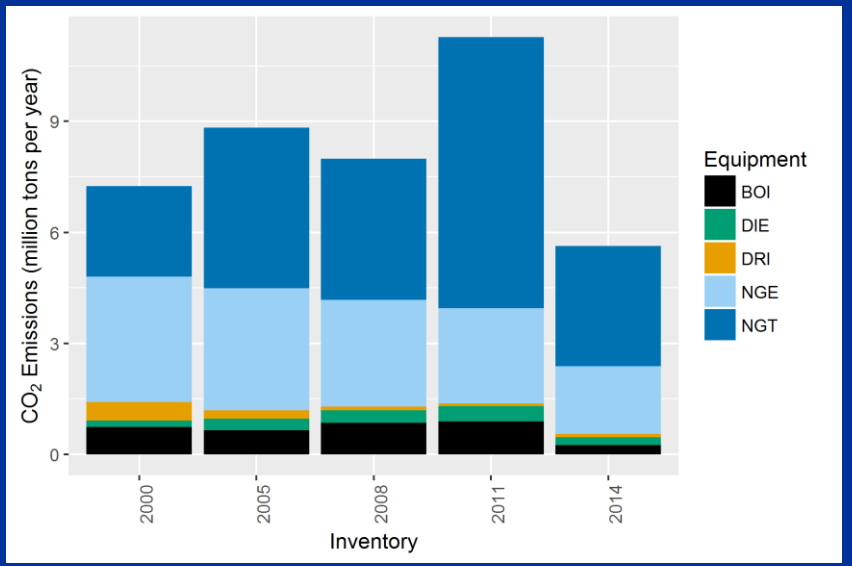


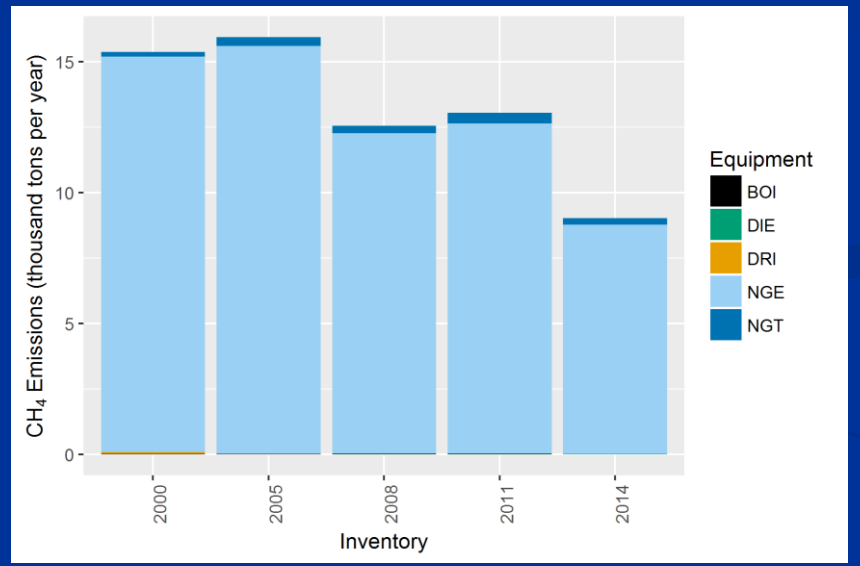
BOEM
Bureau of Ocean Energy Management

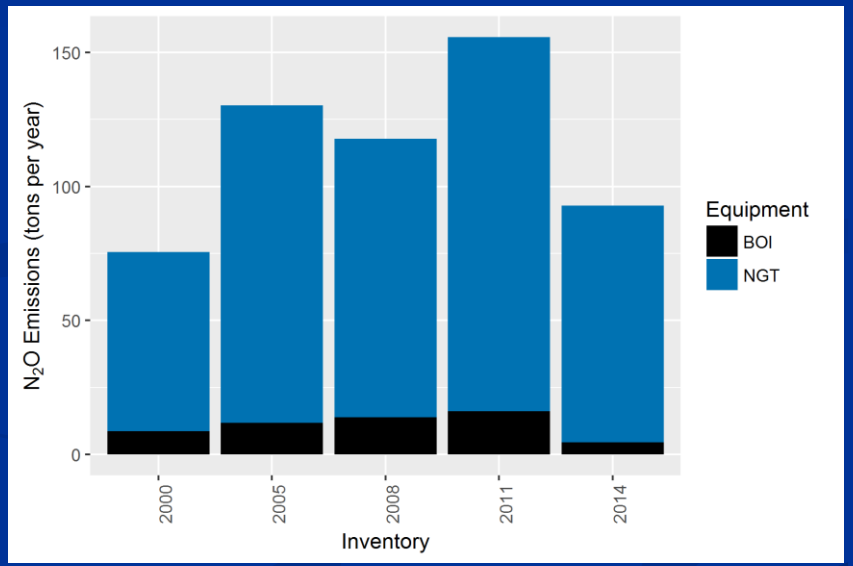
ERG

Platform Sources – by Equipment Type

- Total combustion equipment emissions estimates have been relatively stable
- Large changes in emissions are correlated with changes in activity levels





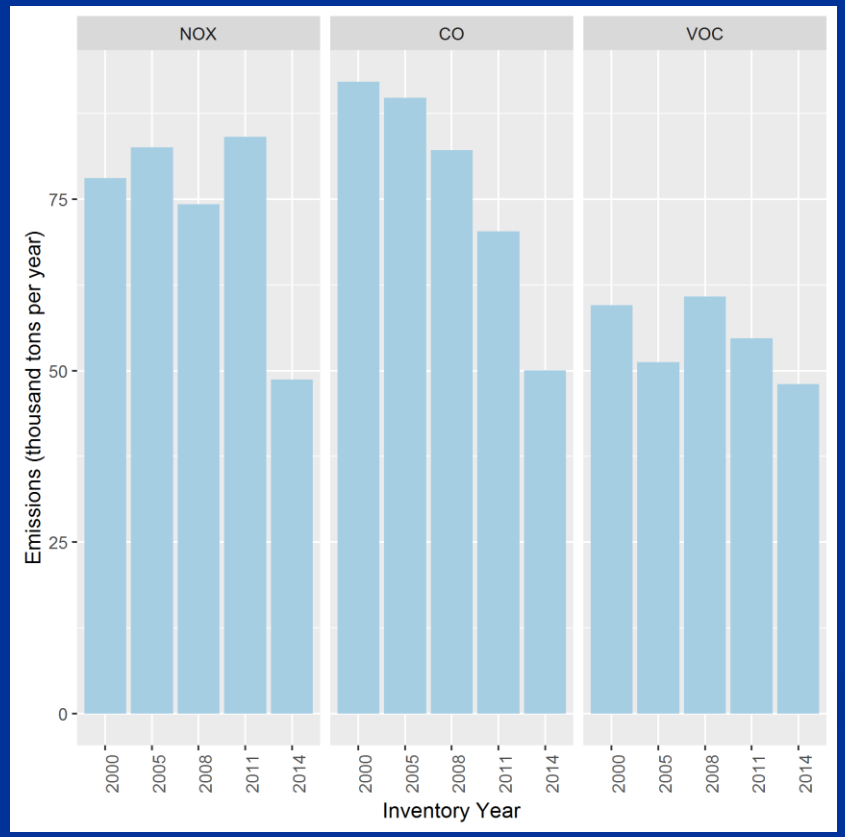


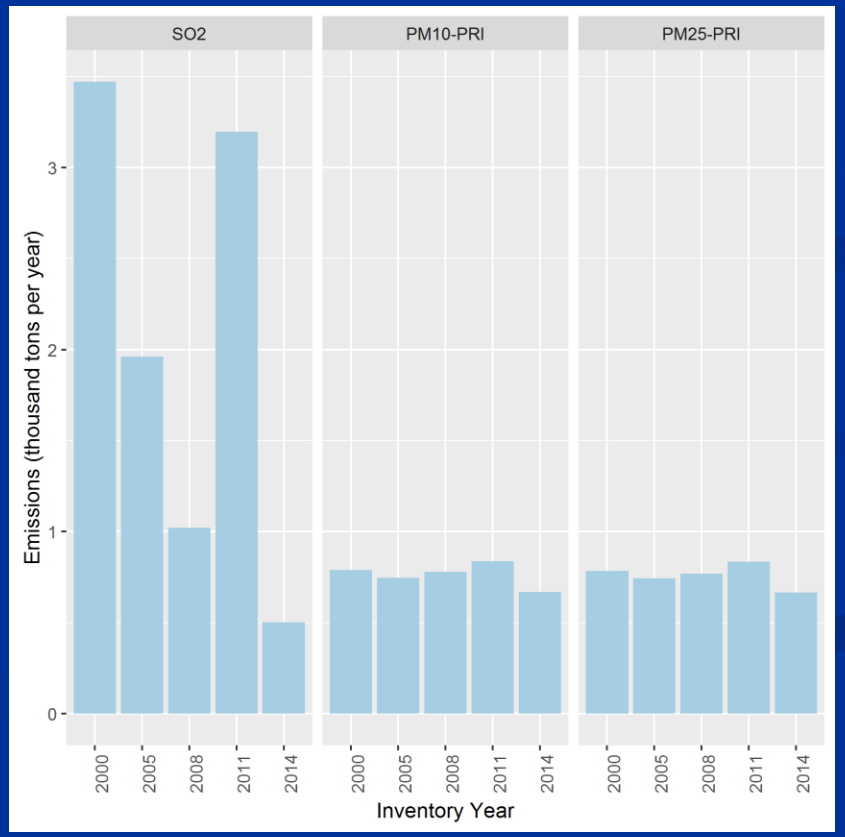
BOEM Bureau of Ocean Energy Management

ERG

Platform Trends – Criteria Pollutant Emissions

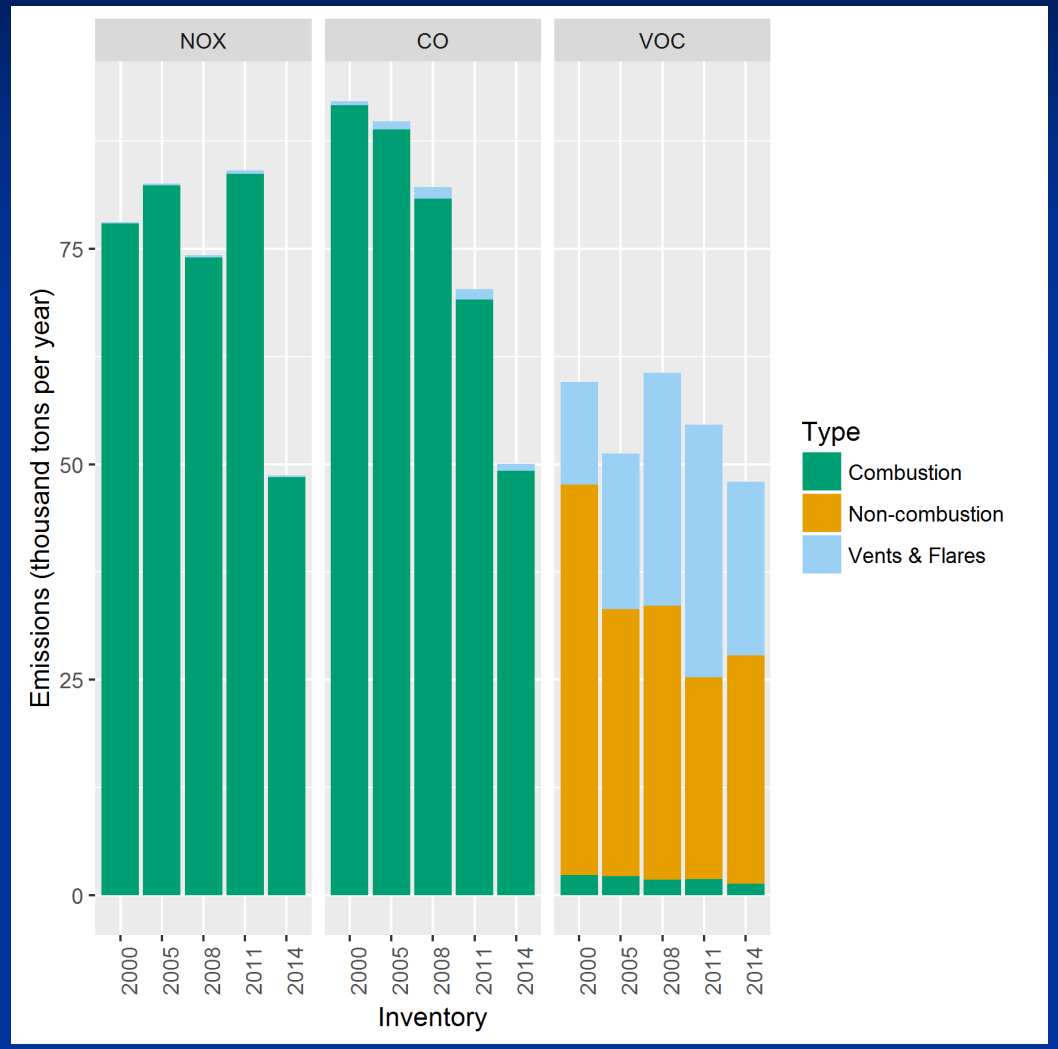
- PM_{10}, $PM_{2.5}$, and VOC have less variability than other CAPs
- SO_2 shows steady decrease except for jump in 2011 inventory

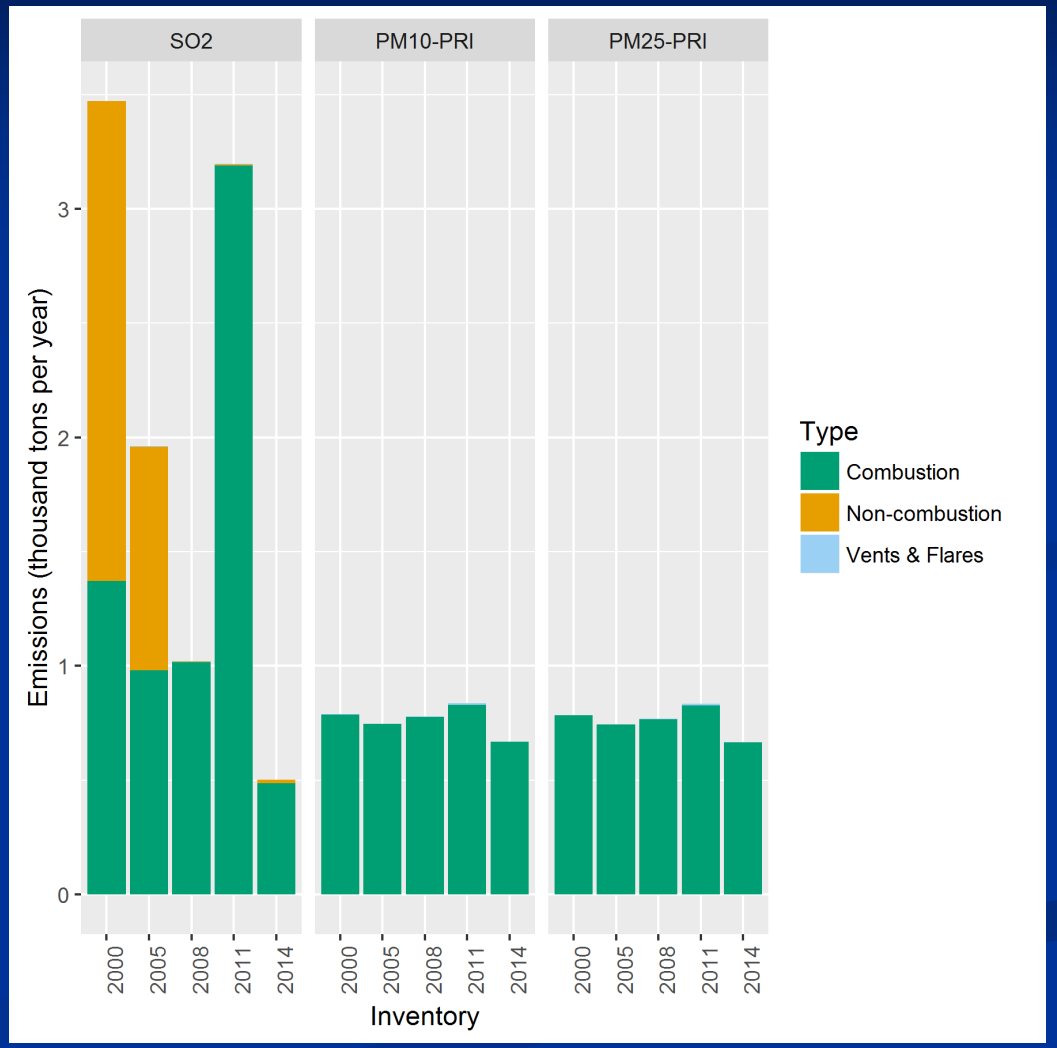




BOEM
Bureau of Ocean Energy Management

Platform Sources – by Type



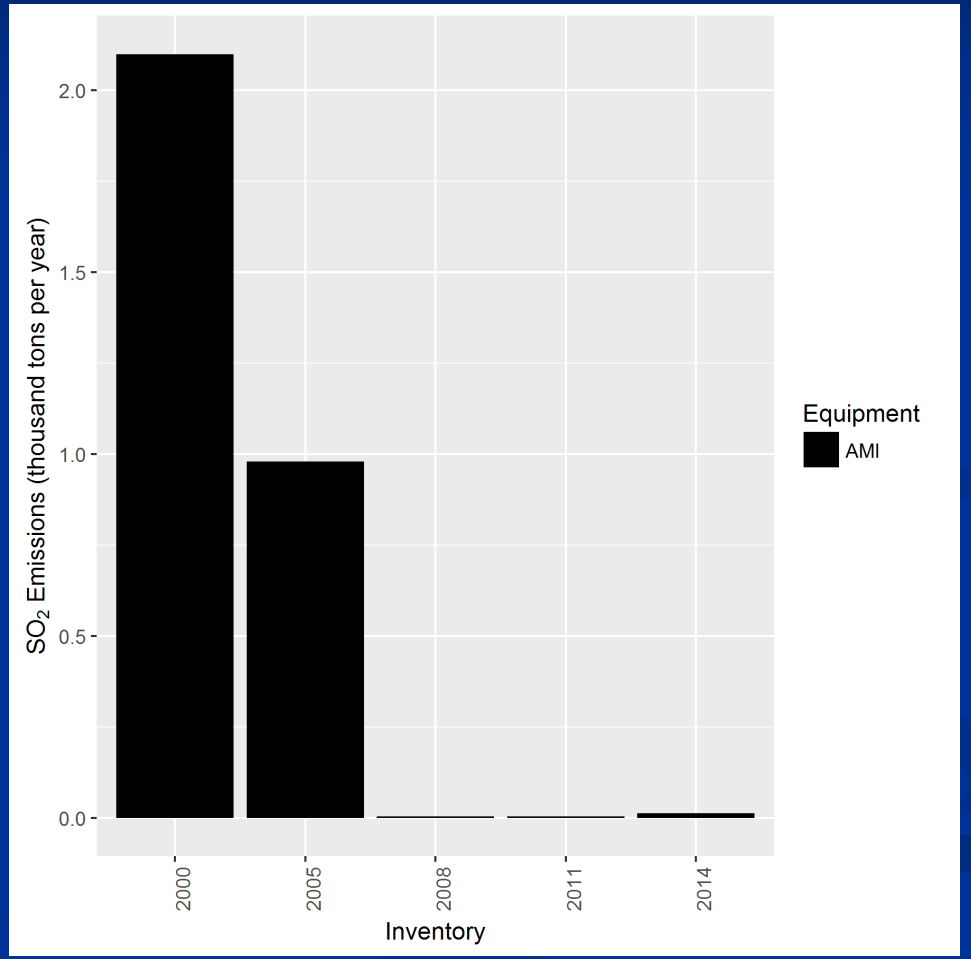


BOEM Bureau of Ocean Energy Management

ERG

Platform Sources – by Equipment Type

- The 43% decrease in SO_2 estimates from amine units in 2005 is explained by the hurricane activity in 2005
- In 2008, one unit that was operating in 2005 (and equipped with a flare) ceased operation and effectively reduced SO_2 emissions from amine units to zero for subsequent inventory years
- The 2014 inventory had an additional amine unit with flared emissions, causing the slight increase in SO_2 estimates

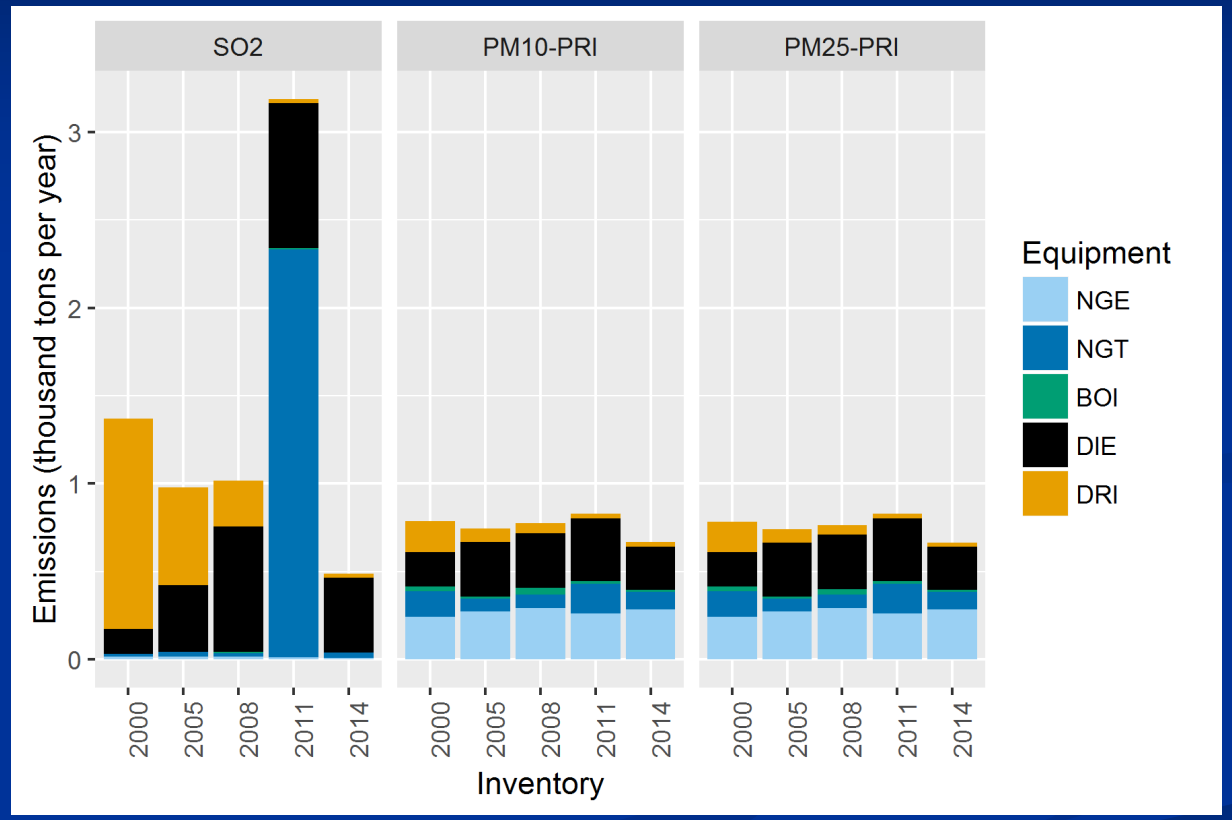


BOEM Bureau of Ocean Energy Management

ERG

Platform Sources – by Equipment Type

- Starting in 2011, diesel and dual-fuel turbines were added to the inventory
- This increased reporting caused an initial spike in SO_2 estimates
- Dropped off again in 2014 with decrease activity and refined reporting



Non-platform Sources

- Composition of the inventories has remained relatively stable
  - Platform construction/removal was removed after 2000 inventory due to overlap with support vessels
- Emergency generators associated with drilling rigs were added to the 2008 inventory as part of total drill rig emissions
- LOOP categories were consolidated after 2000
- Fishing was divided into commercial and recreational since 2011

Non-Platform Source Type	2000	2005	2008	2011	2014
Biogenic & Geogenic Emissions	✓	✓	✓	✓	✓
Commercial Marine Vessels (CMV)	✓	✓	✓	✓	✓
Drilling Rigs	✓	✓	✓	✓	✓
Fishing	✓	✓	✓	✓	✓
Helicopters	✓	✓	✓	✓	✓
Lightering	✓	✓	✓	✓	✓
LOOP	✓	✓	✓	✓	✓
Military Vessels	✓	✓	✓	✓	✓
Pipelaying	✓	✓	✓	✓	✓
Platform Construction/Removal	✓	X	X	X	X
Support Vessels	✓	✓	✓	✓	✓
Survey Vessels	✓	✓	✓	✓	✓

BOEM Bureau of Ocean Energy Management

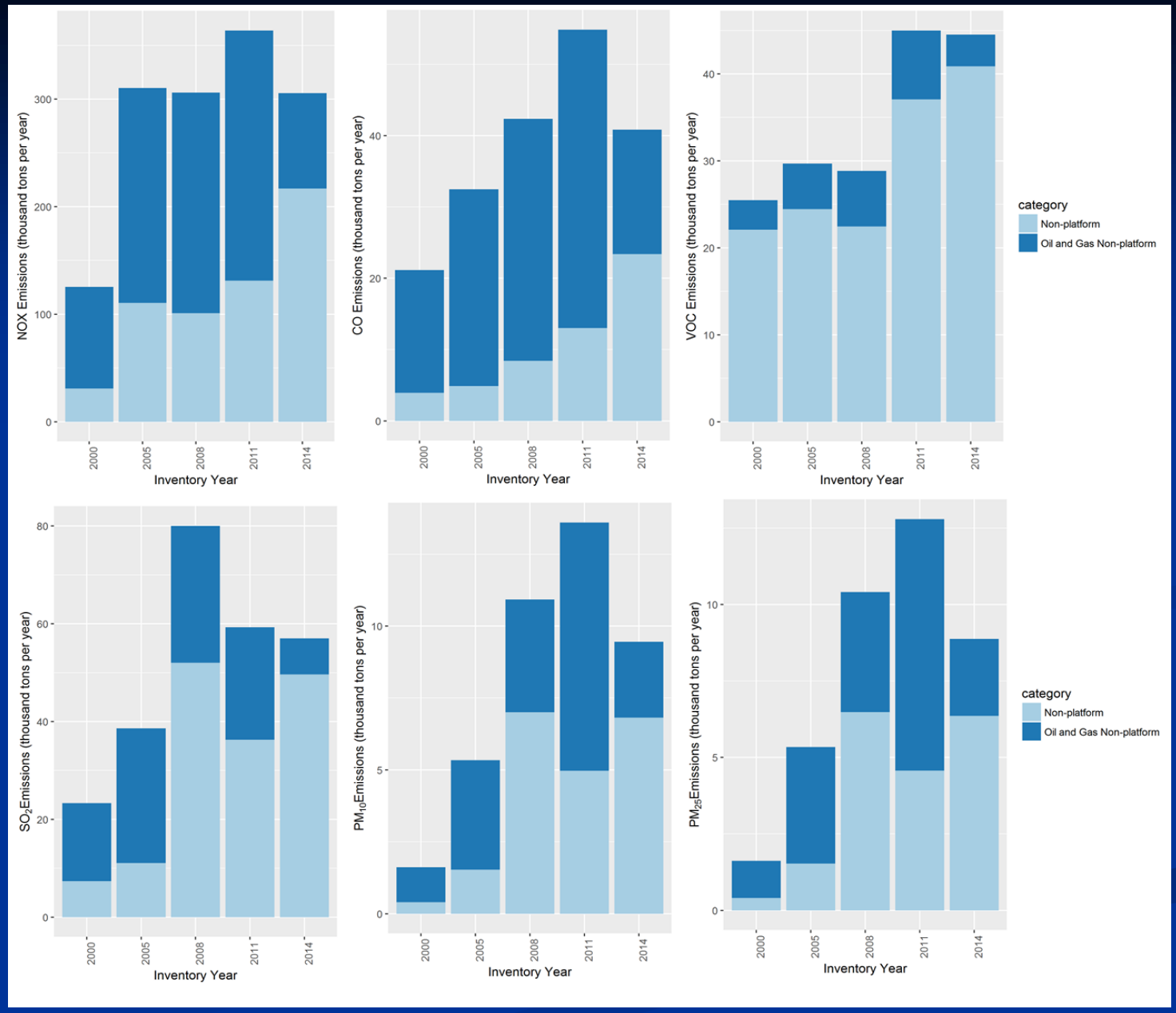
ERG

Trends Analysis – Non-platform Sources

- Most significant changes for non-platform inventory are changes in emission factors, calculation methodology, and activity data
  - FAA helicopter propulsion data for 2005
  - Enhanced drilling rig activity data starting in 2008
  - FOCA data for helicopter emission factors for 2011 and 2014
  - Use of AIS data in 2014

Non-platform Source Type

- Non-BOEM sources make up the majority of the VOC estimates
- For other pollutants, the BOEM/non-BOEM emissions ratio is relatively consistent until 2014



BOEM Bureau of Ocean Energy Management

ERG

Trends Analysis – Non-platform Sources

- The 2014 inventory saw an increase in the portion of emissions attributable to non-BOEM sources due to use of AIS data
- The data used for 2014 allowed for more rigorous differentiation of vessel types, power ratings and engine classifications, and vessel-specific propulsion operating loads
  - AIS identified approximately twice the number of support vessels for 2014 than in the 2011 inventory, while quantifying that the average propulsion engine power rating for these vessels was half of that assumed in the 2011 inventory

BOEM Bureau of Ocean Energy Management

ERG

Trends Analysis – Non-platform Sources

- The 2014 AIS data noted that support vessels tend to idle at sea more than assumed in the earlier inventories yielding significantly lower average engine operating loads
- Even though more vessels were included for 2014, details related to vessel propulsion engines and their operations provided lower emission estimates

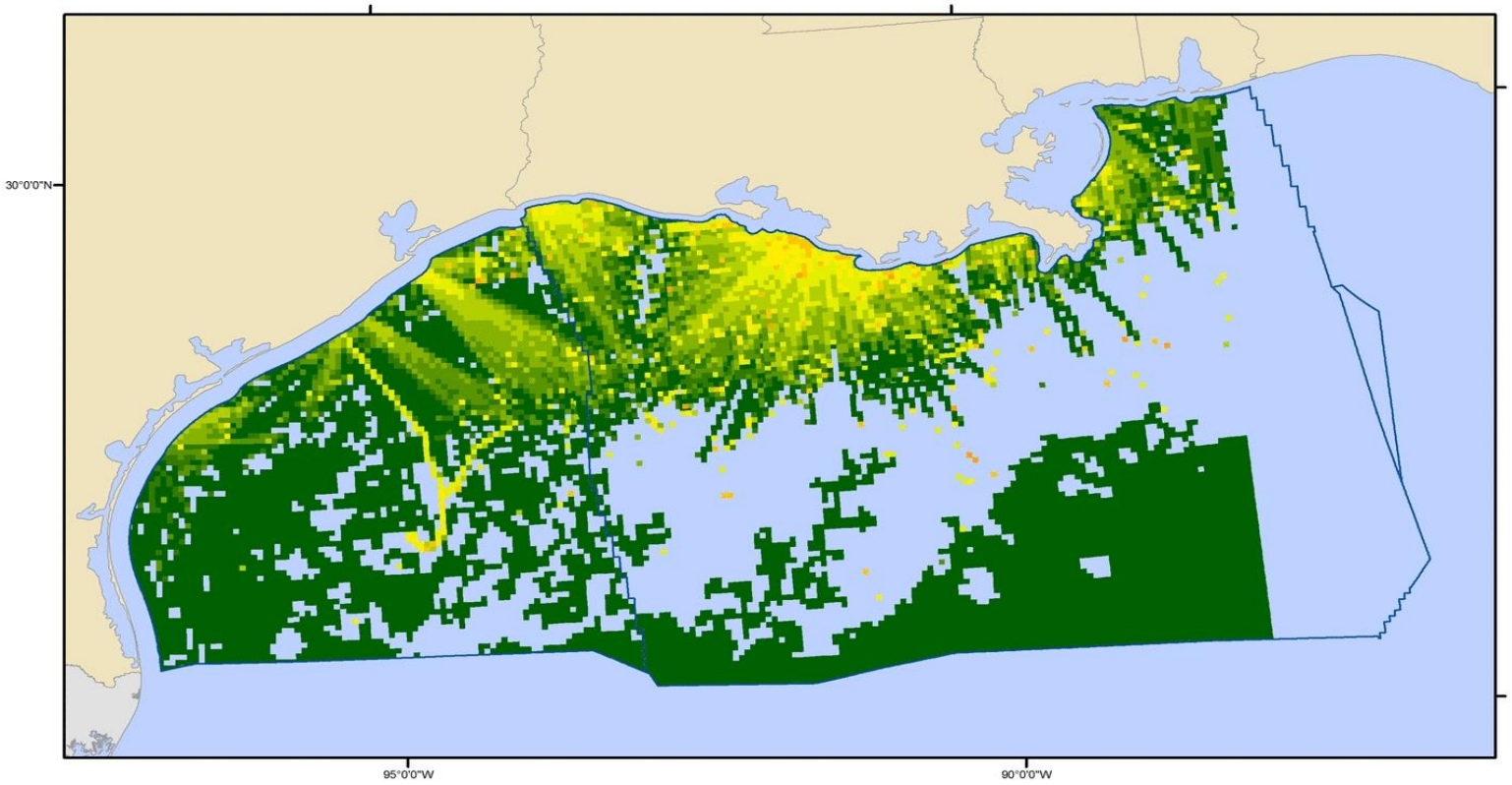
Trends Analysis – Non-platform Sources

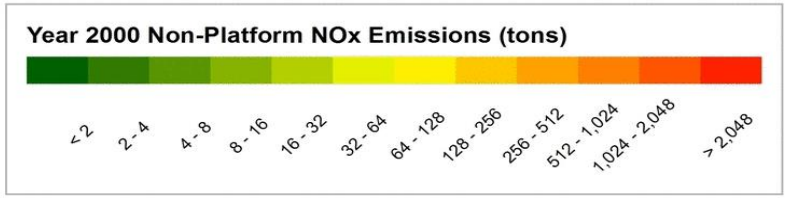
- The spatial distribution of BOEM non-platform emissions has evolved to become more refined over time as the GPS location data have become more specific
- Each year traffic patterns correlate to the routes linked to major ports along the Gulf coast to platforms
- There are several hotspots corresponding to activity surrounding platforms and at pipeline segments where construction or maintenance activities are implemented

BOEM
Bureau of Ocean Energy Management

ERG

Non-platform Spatial Trends



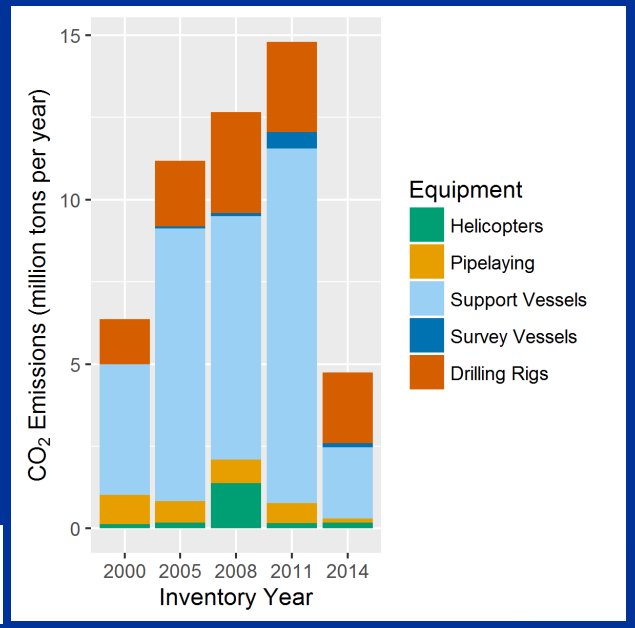


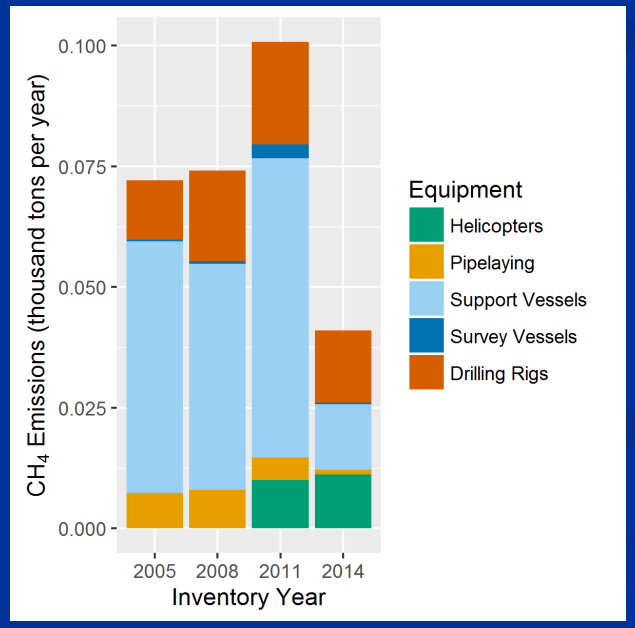
BOEM
Bureau of Ocean Energy Management

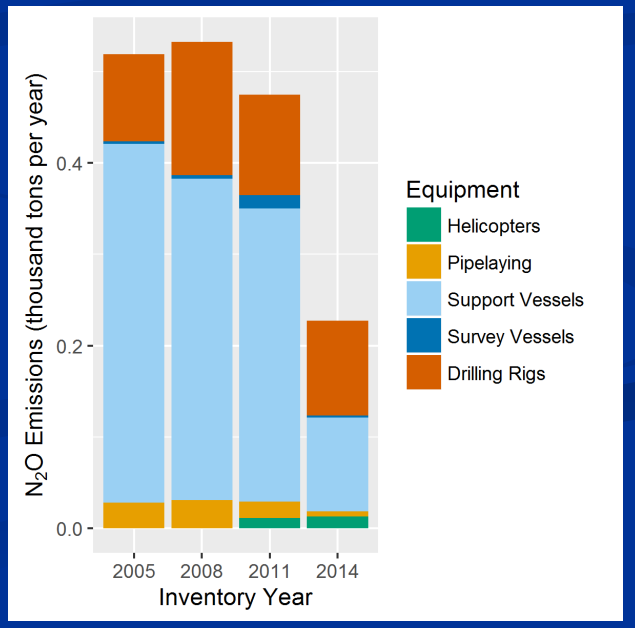
ERG

Non-platform GHG – By Vessel Type

- CH_4 and N_2O were not included in 2000 for BOEM non-platform sources due to lack of vetted emission factors
- Support vessels are the largest contributor to GHG estimates for all inventory years
- All non-platform sources had higher GHG emissions estimates in 2008 than in 2005, except for support vessels, which is indicative of a reduction in the Gulf fleet



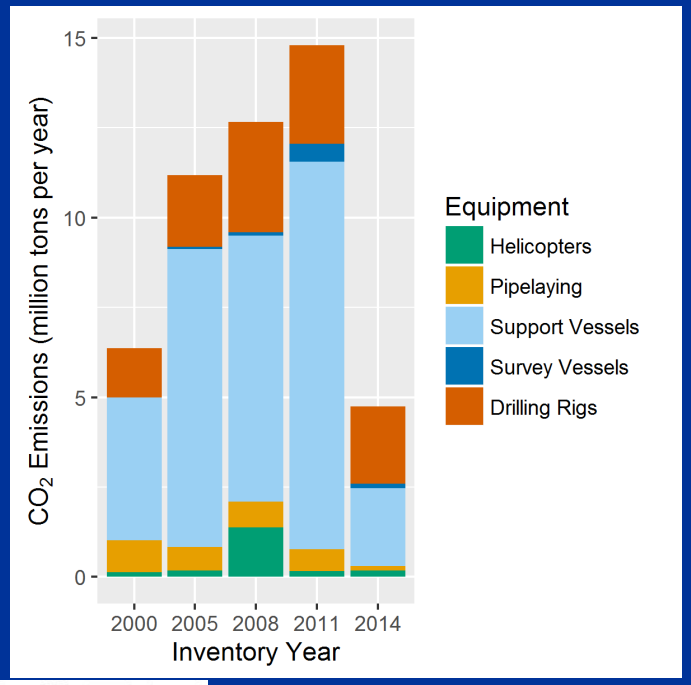


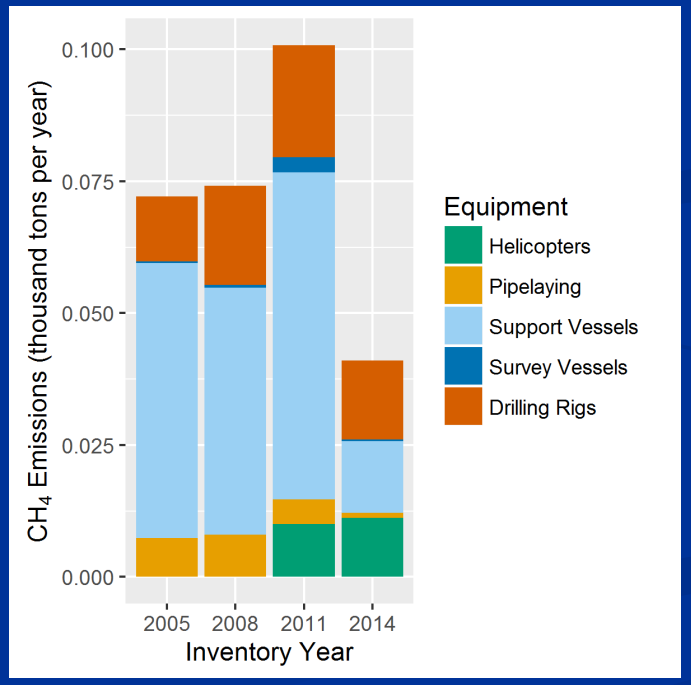


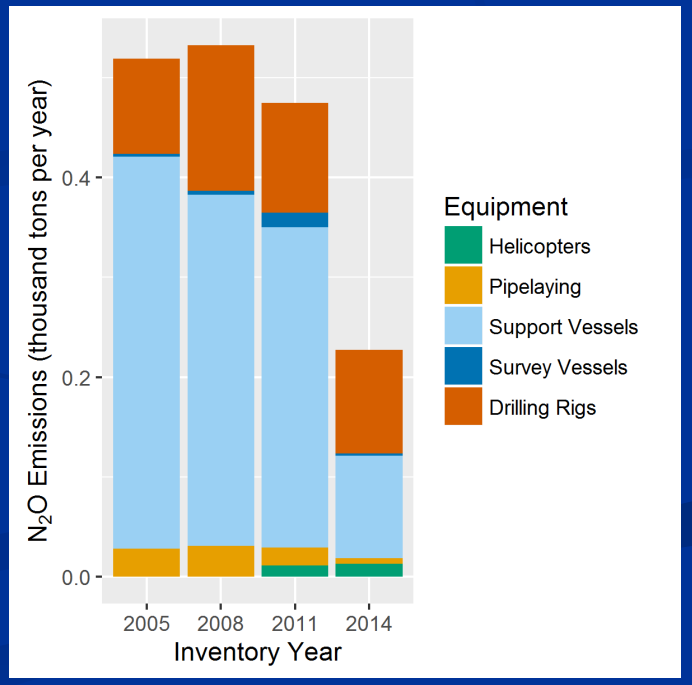
BOEM
Bureau of Ocean Energy Management

Trends Analysis – Non-platform Sources

- In 2011, the USEPA emission factors for helicopters and vessels were updated to reflect newer vessels and fuel standards
- This update along with increased activity yielded an overall increase in GHG estimates for 2011





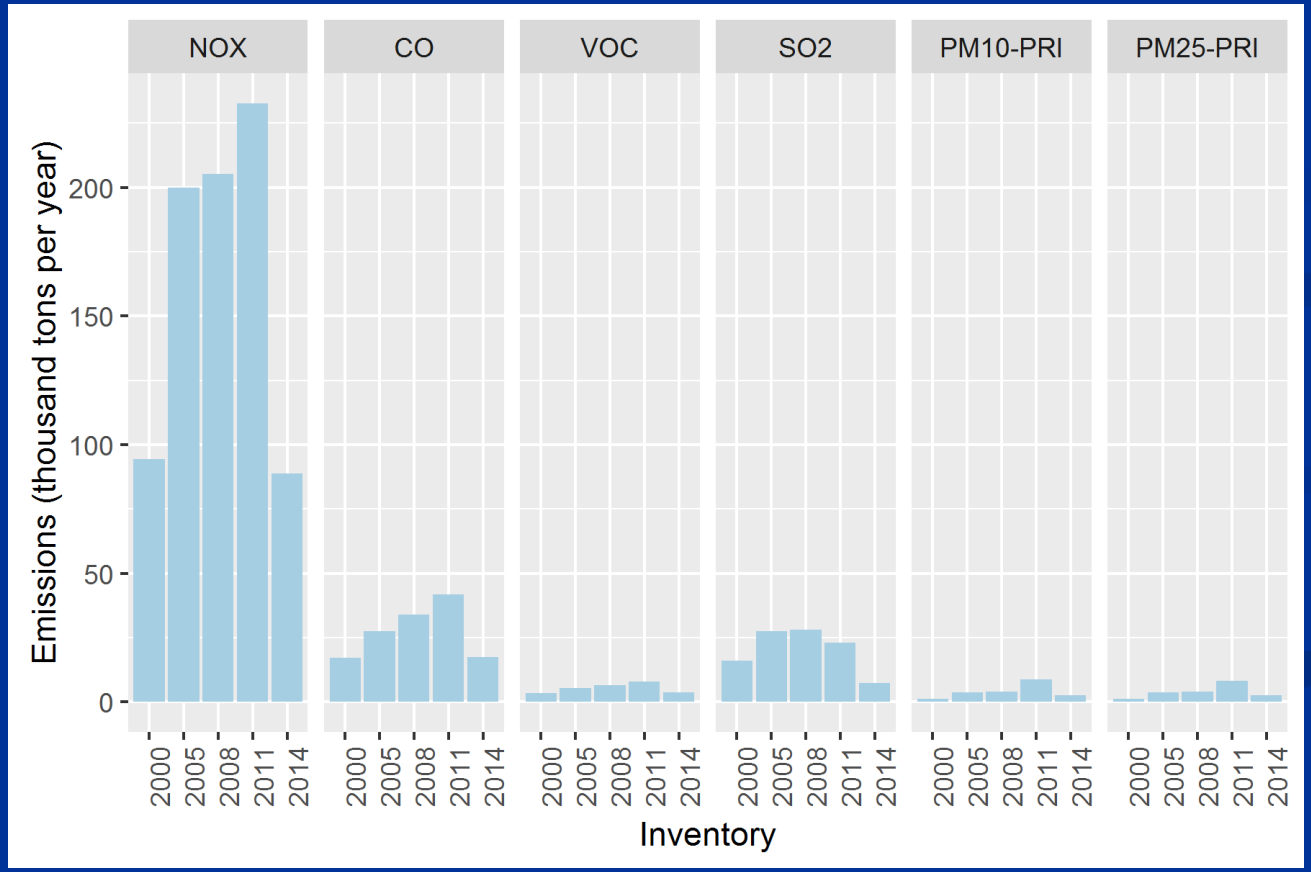


BOEM
Bureau of Ocean Energy Management

ERG

Trends Analysis – Non-platform Sources

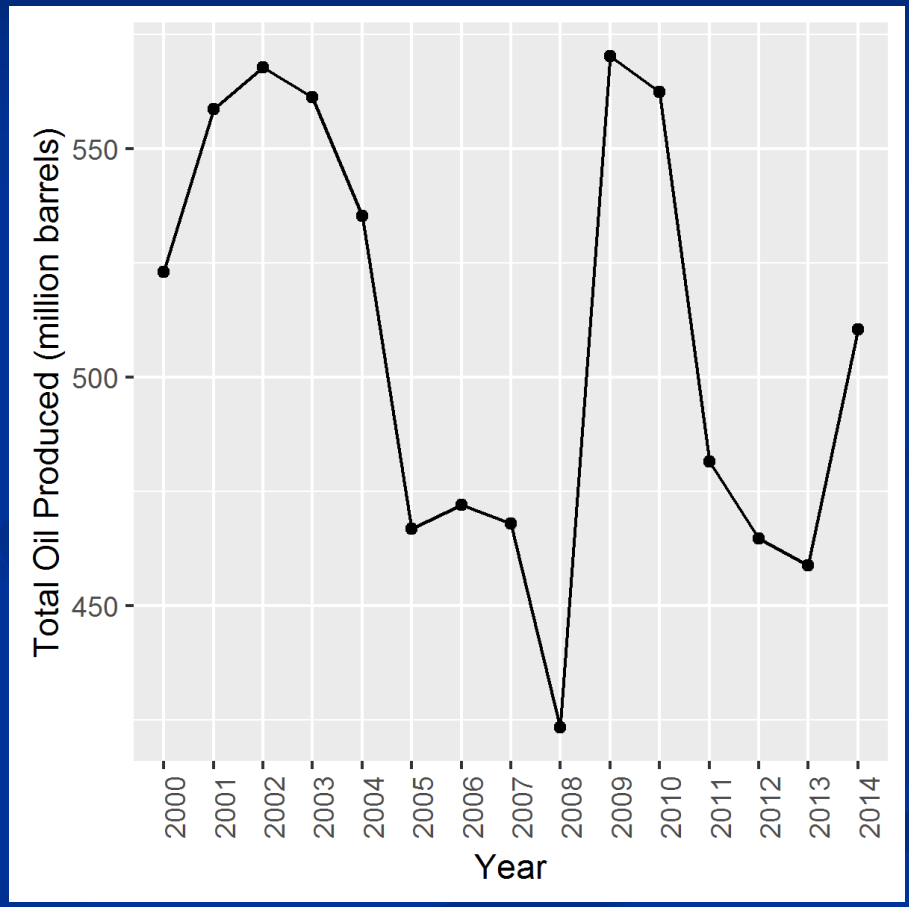
- With the exception of SO_2, criteria pollutant estimates increased for BOEM non-platform sources from 2000 to 2011, and decreased from 2011 to 2014
- SO_2 estimates decreased in 2011 due to lower fuel sulfur standards and continued to decrease in 2014



BOEM
Bureau of Ocean Energy Management

Trends Analysis

- A key factor to the emissions trend is total production of oil and gas, as the amount produced will impact the activity data used to estimate emissions
- Oil production has oscillated since 2000
  - 2000 and 2014 inventory years represent years with increasing production
  - 2005, 2008, and 2011 are years with decreasing production trends

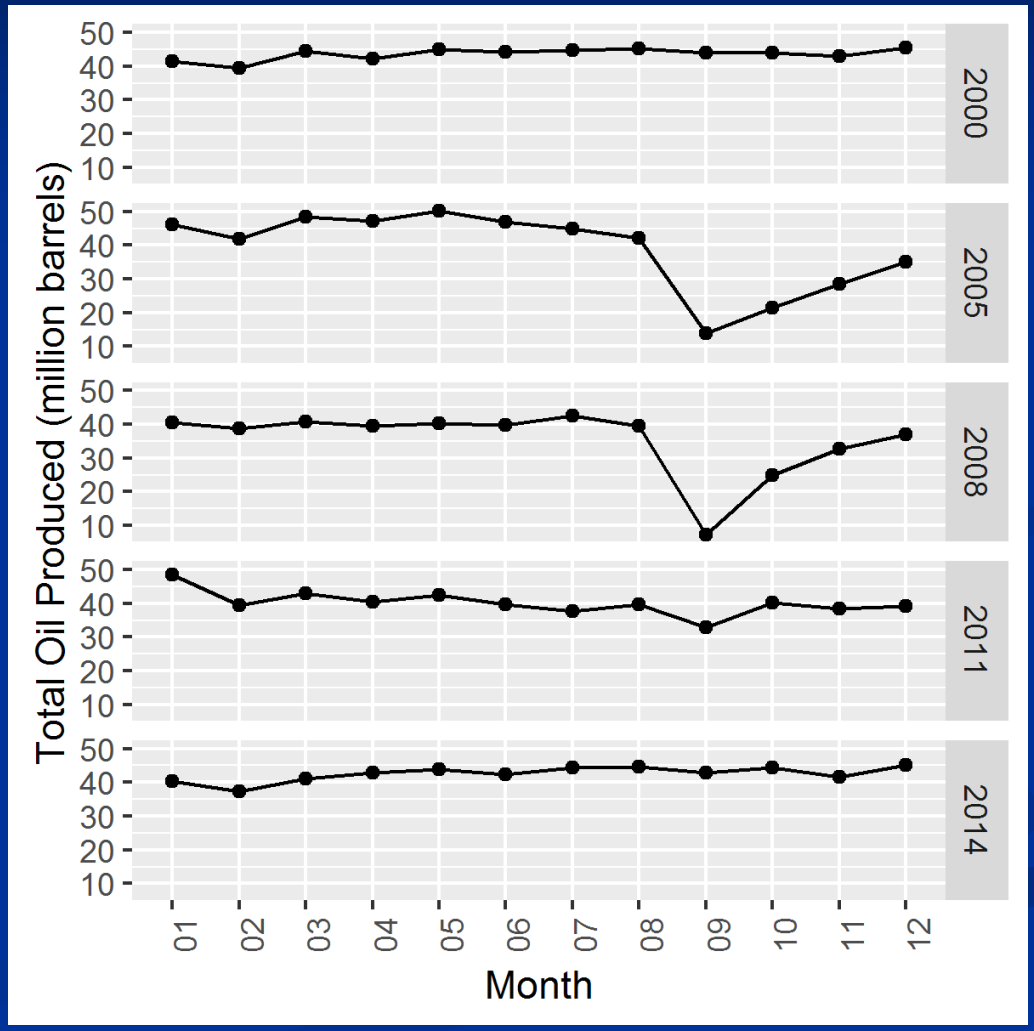


BOEM Bureau of Ocean Energy Management

ERG

Trends Analysis

- The drop in oil production in September of 2005 is likely due to hurricanes Katrina and Rita
- The drop in oil production in September of 2008 is likely due to hurricanes Gustav and Ike
- These drops in production contribute to a drop in emissions during these years



BOEM Bureau of Ocean Energy Management

ERG

Trends Analysis – Regression Analysis

- Production or price of oil seemed like good predictors of emissions, because both parameters could qualitatively be related to activity and emissions level
- However, these did not prove to be robust indicators with simple linear regressions
- Further investigation is necessary to find the cause of the lack of correlation between production and emissions, or to find a more suitable proxy for activity level

Trends Analysis – Regression Analysis

- The year 2000 inventory qualitatively appears to be an outlier that can shift a regression to produce a lower correlation
- To a lesser extent, 2014 also seems out of line with trends set in earlier inventories
  - NO_x correlation plots for 2014 show low emissions paired with high values of price, production, and production per platform
  - It is likely this is a new trend emerging in the inventories, and bears watching in the future inventories

BOEM Bureau of Ocean Energy Management

ERG

Results: Emissions Trends Analysis

- Platform and non-platform sources and emissions were compared for the 2000, 2005, 2008, 2011, and 2014 inventory years
- Overall, emissions are largely affected by three factors:
  - Activity/production levels by water depth and planning area
  - Changes in inventory methodologies
  - Improvements in available emission factors

ANY QUESTIONS?

BOEM
Bureau of Ocean Energy Management

ERG