

Methods to Estimate Emissions for Vessels Equipped with Category 1 & 2 Propulsion Engines Based on AIS Activity Data

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2019 International Emission Inventory Conference
Dallas, Texas. July 30-August 2, 2019

Overview

AIS Data Cleaning

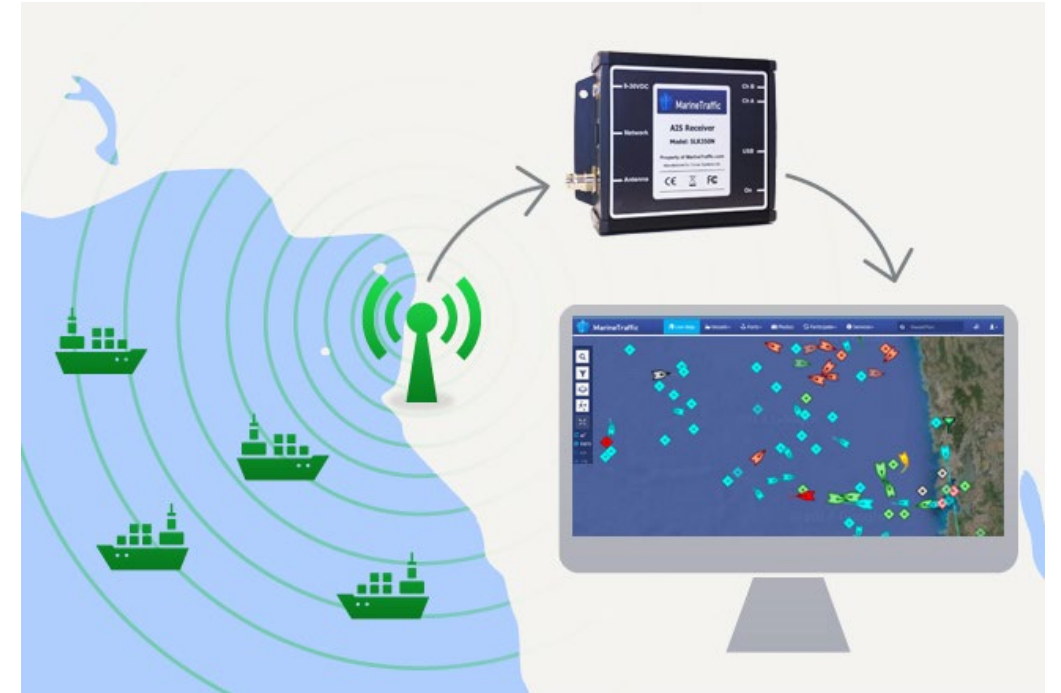
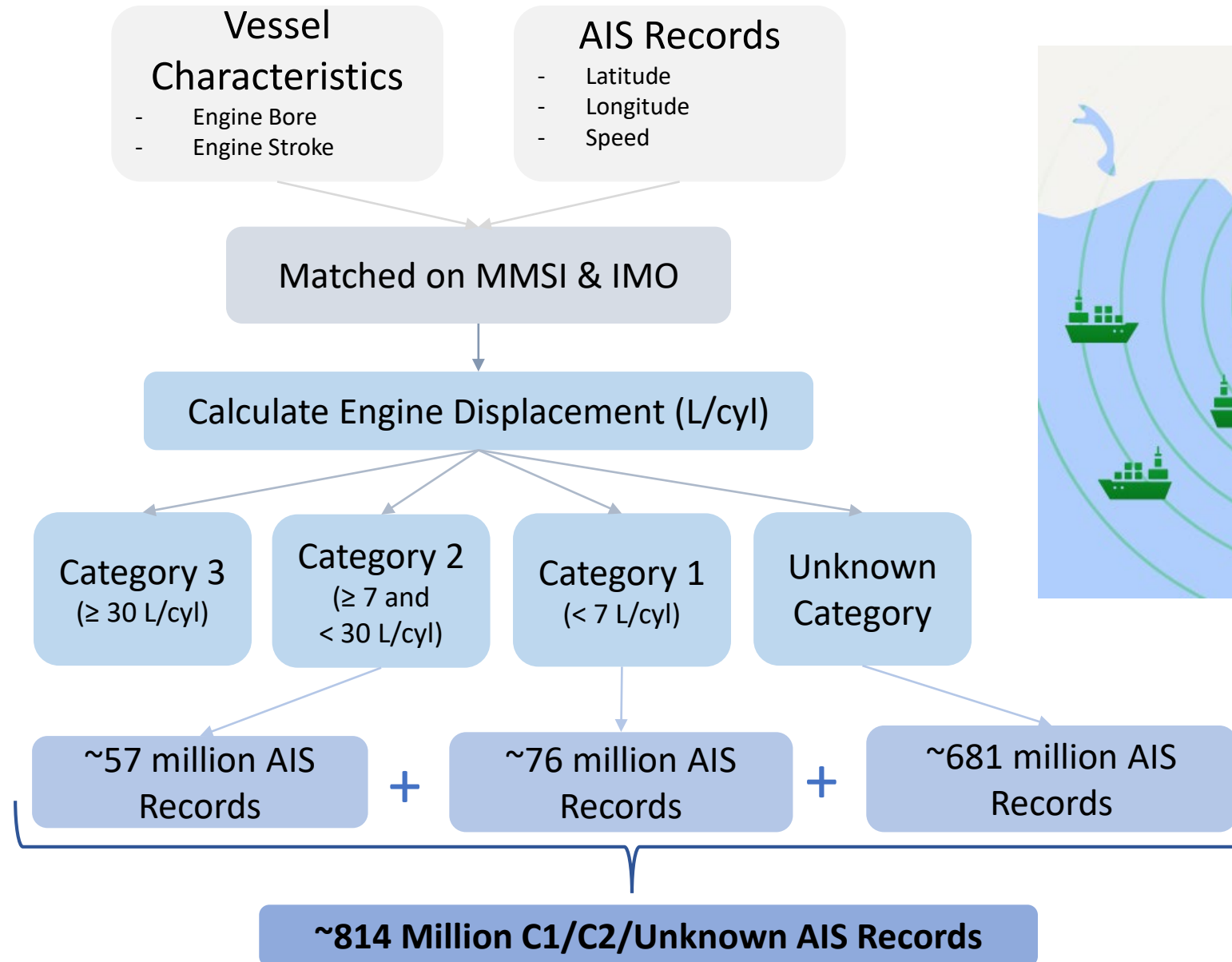
Vessel Type Identification

Power Surrogates

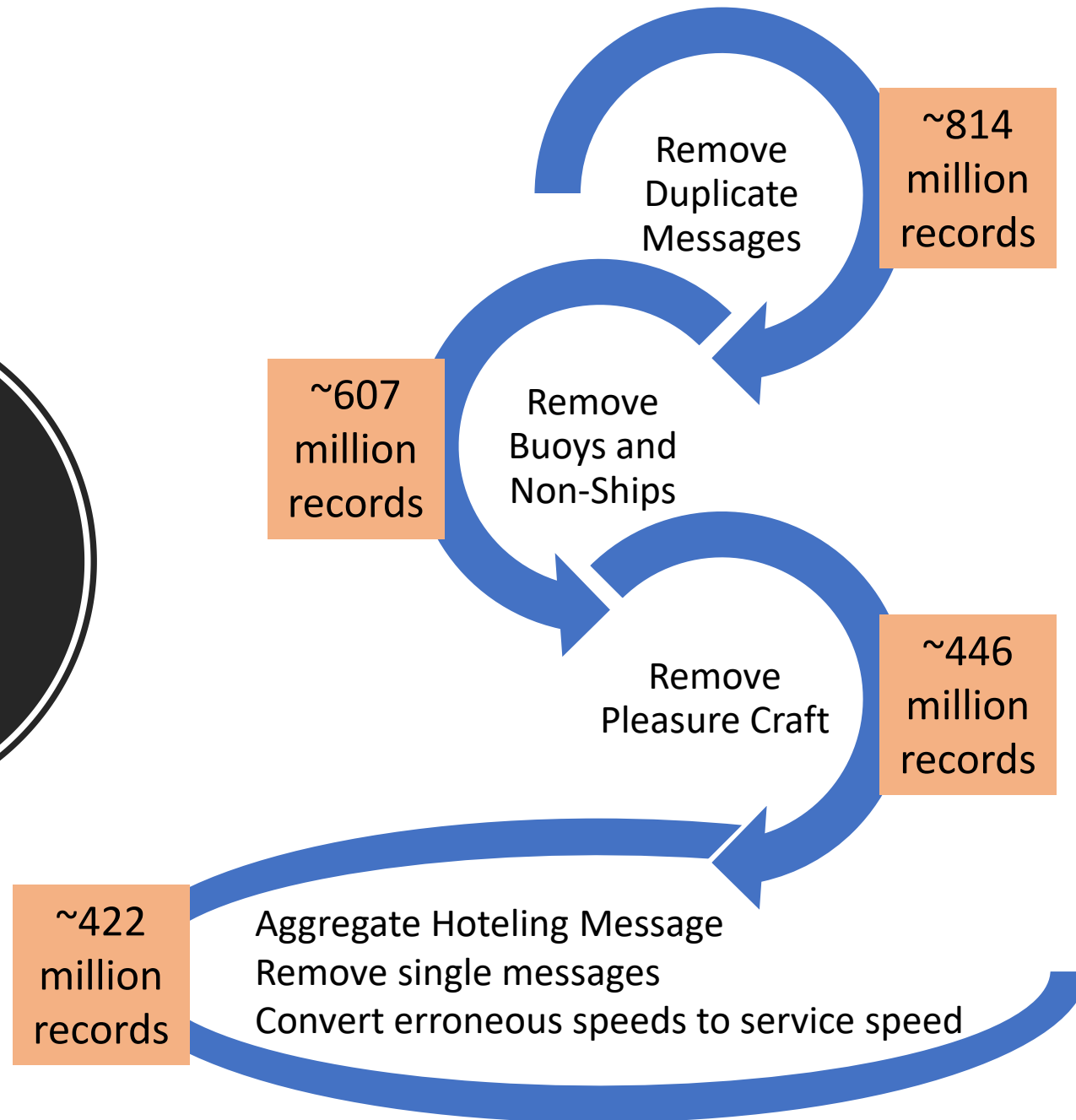
Emission Factors

Rasterization & Results

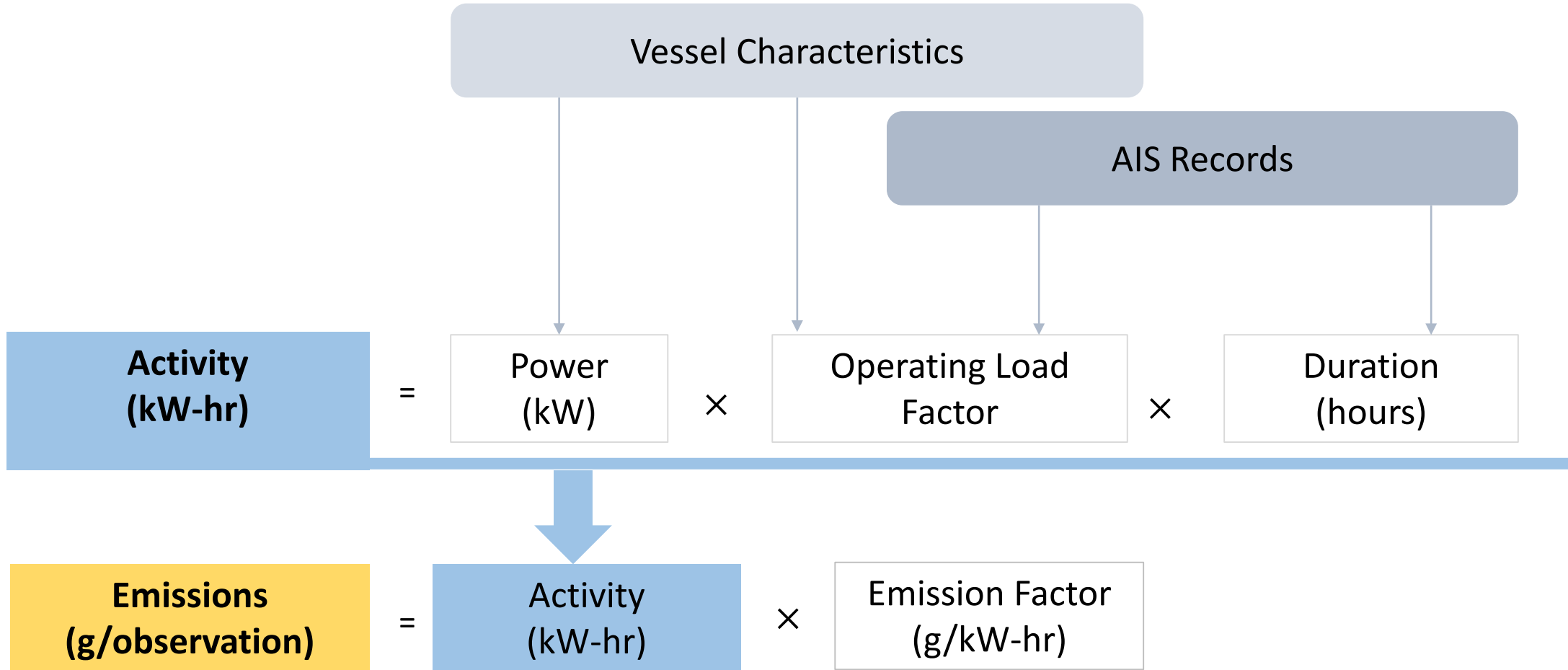
Automated Identification System (AIS)



AIS Data Cleaning

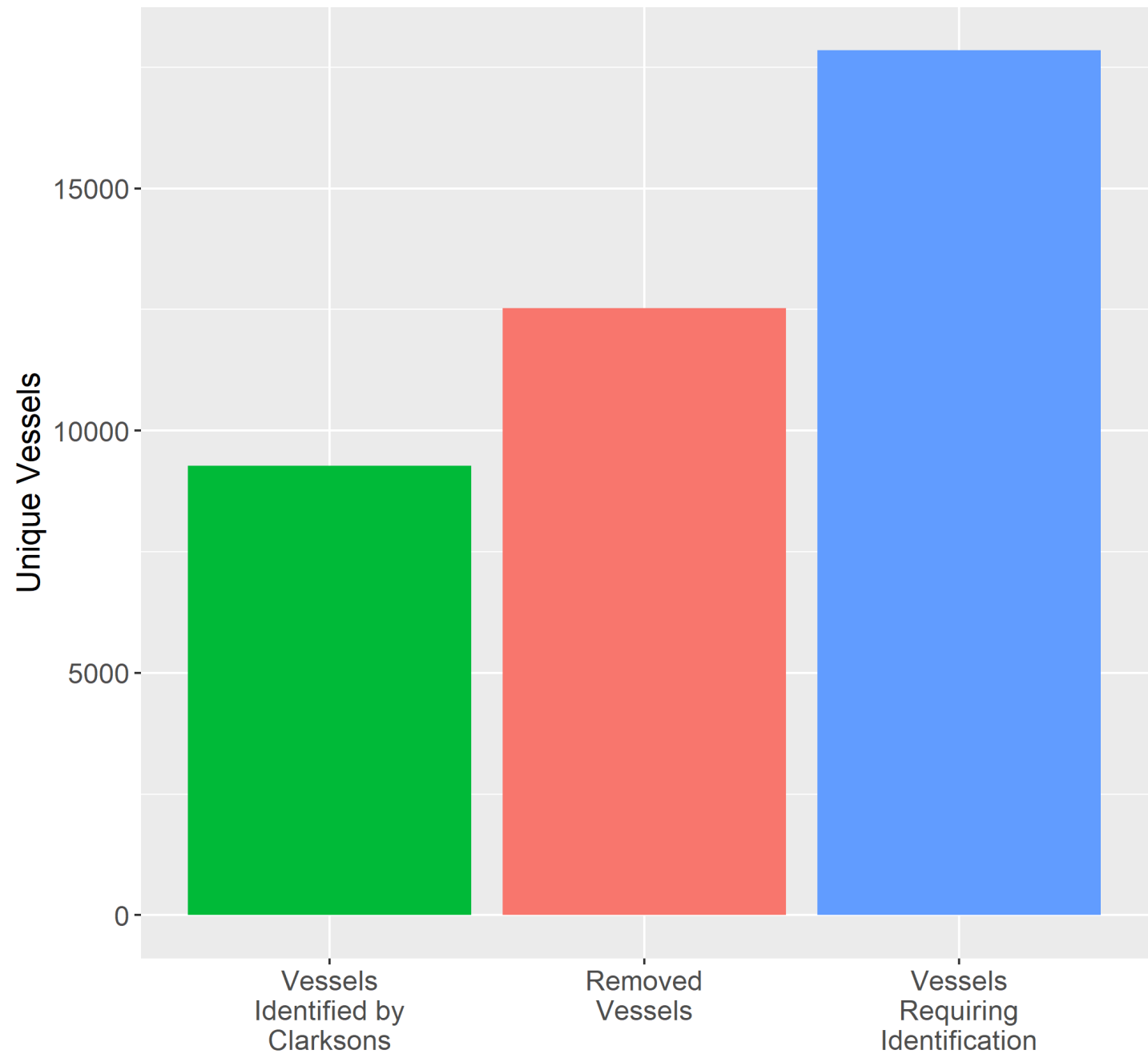


Emissions Calculations



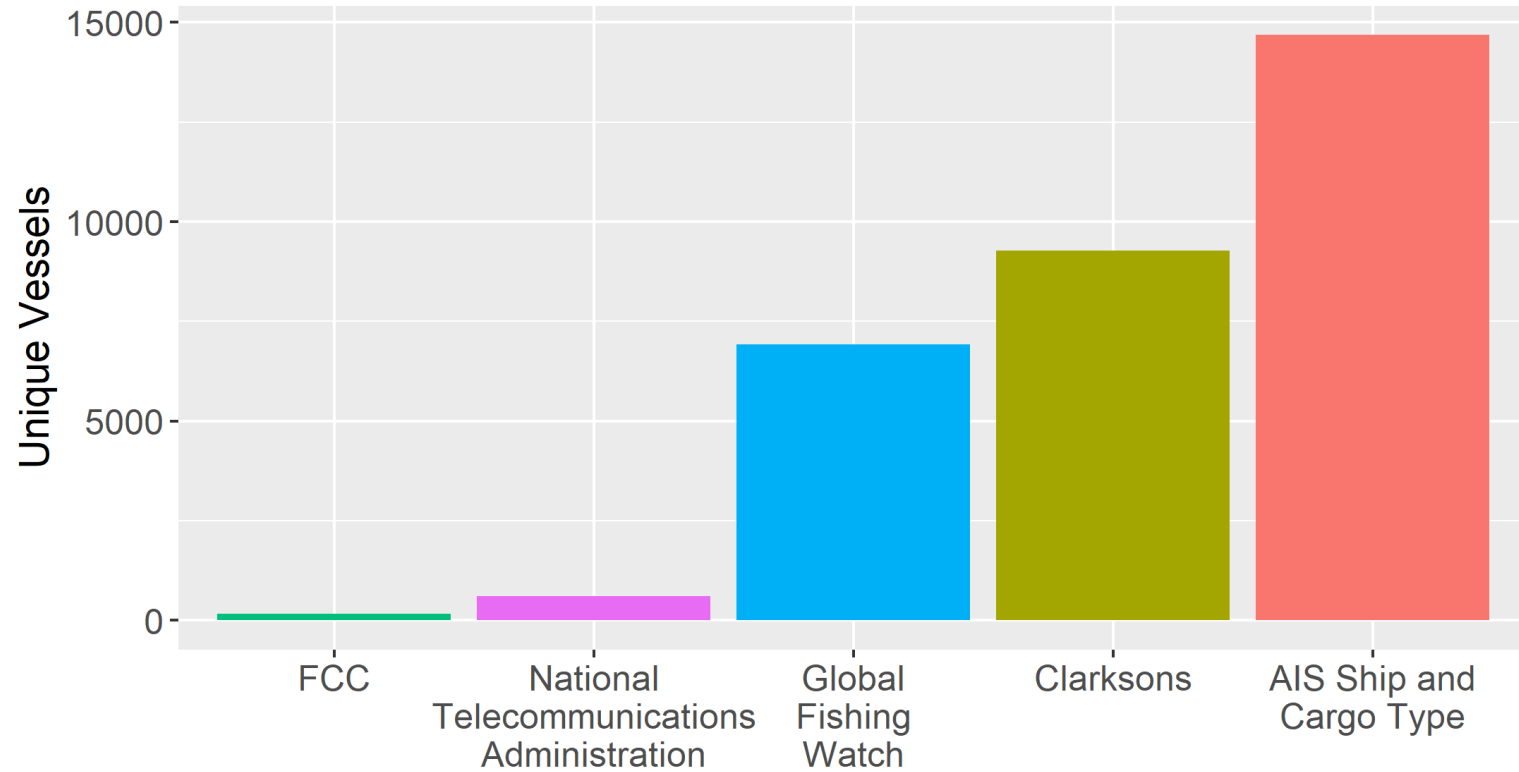
Vessel Type Identification

C1 C2 Vessel Identification Needs

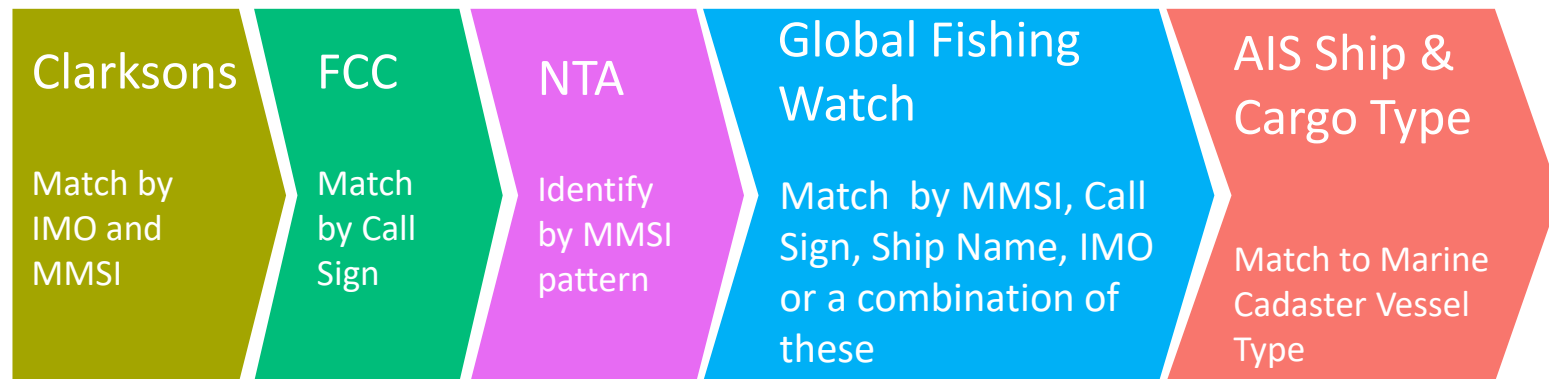


Vessel Type Identification

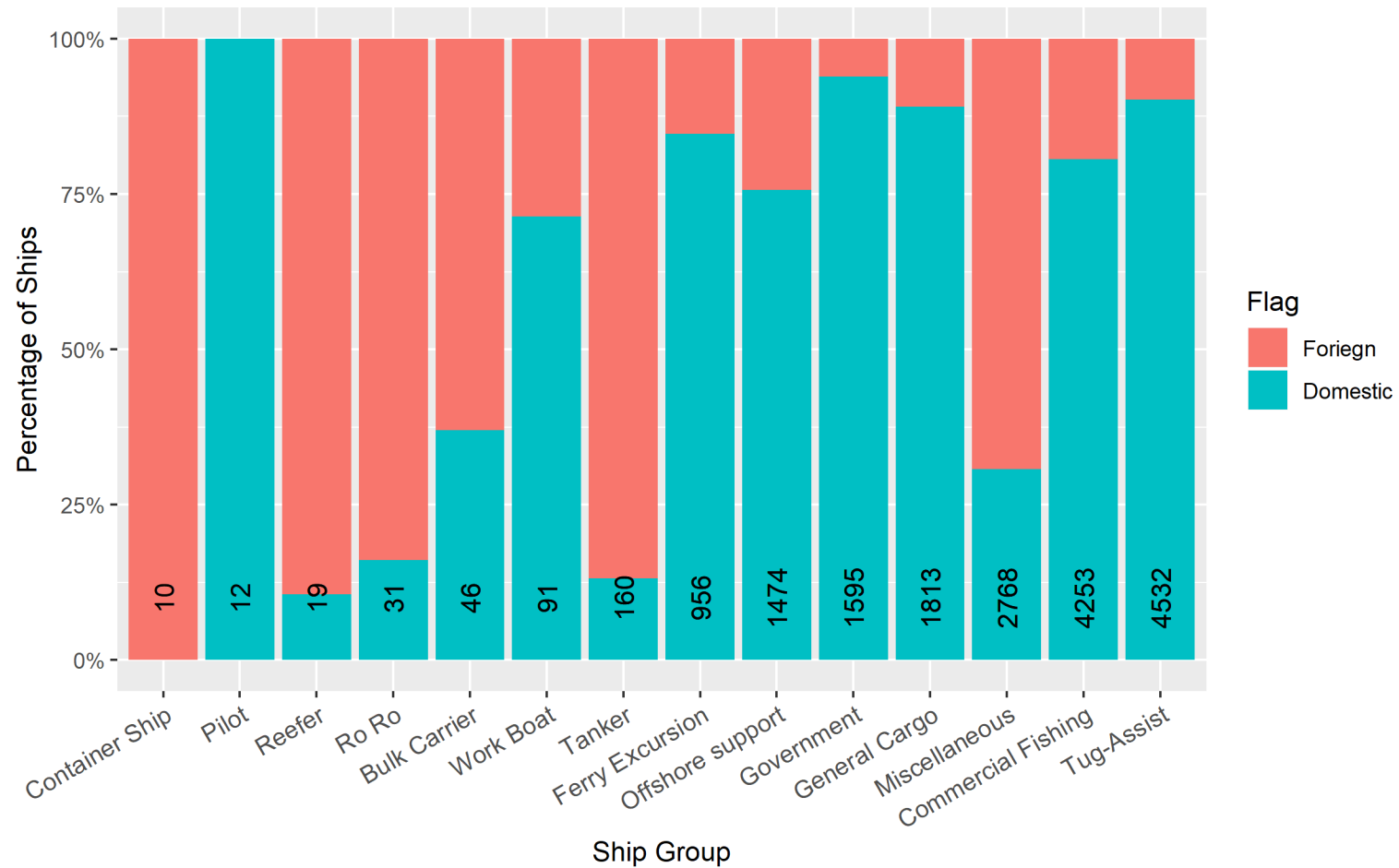
C1 C2 Marine Vessel Identification



Vessel Identification Methods

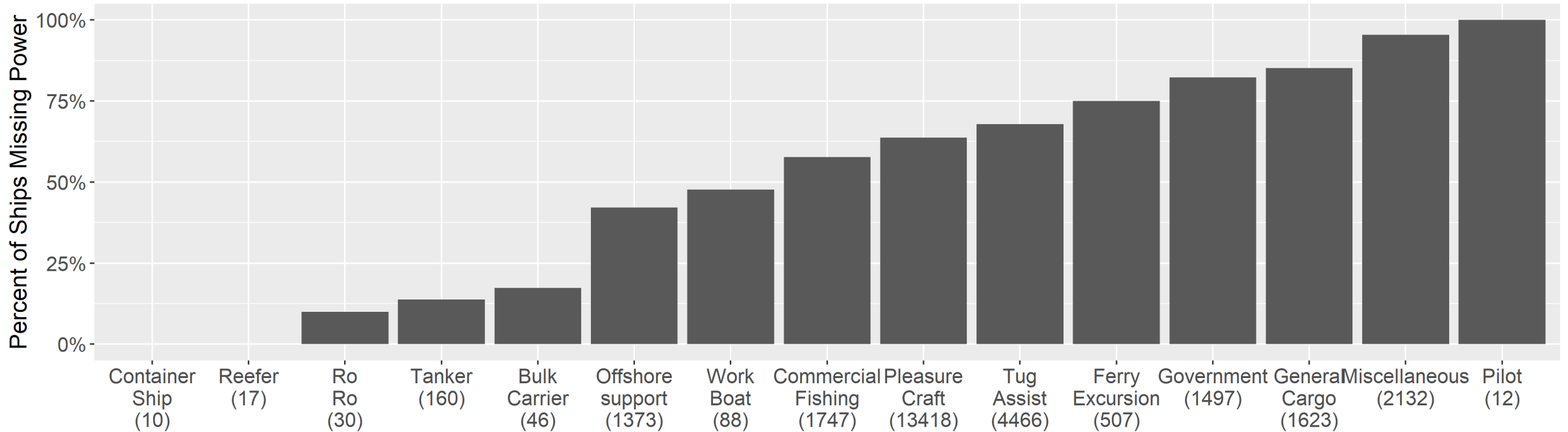


Vessel Group Assignment

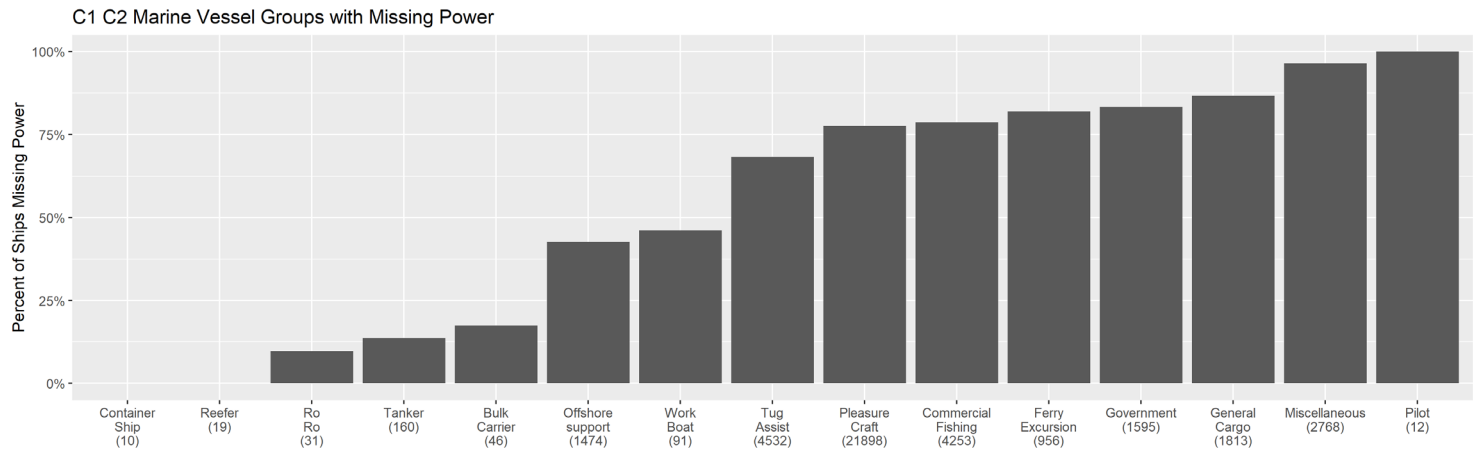


Vessels Missing Power Data

C1 C2 Marine Vessel Groups with Missing Power



Power Surrogates



Vessel Group	Avg Build Year	Tier	Prop Power (kW)	Aux Power (kW)	Aux Operating Load	Boiler (kW)
Bulk Carrier	1976	0	7505	1009	0.10	109
Commercial Fishing	1987	0	520	567	0.56	
Container Ship	1994	0	2700	594	0.19	506
Ferry Excursion	1995	0	5322	1385	0.56	
General Cargo	1986	0	2396	1120	0.22	106
Government	1998	0	2125	2313	0.56	
Miscellaneous	1999	0	2337	1069	0.56	
Offshore support	1999	0	3949	1081	0.56	
Pilot		0	868	20	0.56	
Reefer	1992	0	5877	2854	0.32	464
Ro Ro	1985	0	3793	695	0.26	109
Tanker	2003	0	6578	2399	0.26	346
Tug	1992	0	2395	162	0.56	
Work Boat	1989	0	3546	1492	0.56	

Main Engine Emission Factors

Model Year	Tier	NOX	VOC	CO	PM10	PM25	SO2	CO2
Older than 2004	Tier 0	13.36	0.14	2.48	0.21	0.20	0.00624	679.56
2004-2006	Tier 1	10.55	0.14	2.48	0.21	0.20	0.00624	679.56
2007-2012	Tier 2	8.33	0.14	2.03	0.31	0.30	0.00624	679.56
2013-2016	Tier 3	6.35	0.08	2.03	0.20	0.19	0.00624	679.56
Newer than 2017	Tier 4	1.30	0.02	2.03	0.11	0.11	0.00624	679.56

Auxiliary Engine Emission Factors

Tier	NOX	VOC	CO	PM10	PM25	CO2	SO2	HC	N2O	BC	BSFC
Tier 0	10.28	0.30	1.61	0.26	0.25	679.47	0.01	0.28	0.03	0.19	248.18
Tier 1	9.62	0.30	1.61	0.26	0.25	679.47	0.01	0.28	0.03	0.19	248.18
Tier 2	5.64	0.30	0.92	0.15	0.14	679.47	0.01	0.28	0.03	0.11	248.18
Tier 3	4.75	0.12	0.92	0.08	0.08	679.47	0.01	0.12	0.03	0.06	248.18
Tier 4	1.30	0.12	0.92	0.03	0.03	679.47	0.01	0.12	0.03	0.02	248.18

Boiler Engine Emission Factors

NOX	VOC	CO	PM10	PM25	CO2	SO2	Pb	N2O	CH4	NH3
2	0.11	0.2	0.2	0.19	961.8	0.59	0.00005	0.08	0.002	0.0004

Emission Factors

Updated with the Port Inventory Guidance and then population weighted average emission factors across different engine sizes

New Commercial Marine Vessel

Source Classification Codes (SCC)

New SCC	Fuel	Category	Port/ Underway	Engine
2280002101	Diesel	C1/C2	Port	Main
2280002102	Diesel	C1/C2	Port	Aux
2280002201	Diesel	C1/C2	Underway	Main
2280002202	Diesel	C1/C2	Underway	Aux
2280002103	Diesel	C3	Port	Main
2280002104	Diesel	C3	Port	Aux
2280002203	Diesel	C3	Underway	Main
2280002204	Diesel	C3	Underway	Aux
2280003103	Residual	C3	Port	Main
2280003104	Residual	C3	Port	Aux
2280003203	Residual	C3	Underway	Main
2280003204	Residual	C3	Underway	Aux

Development of HAP Profiles

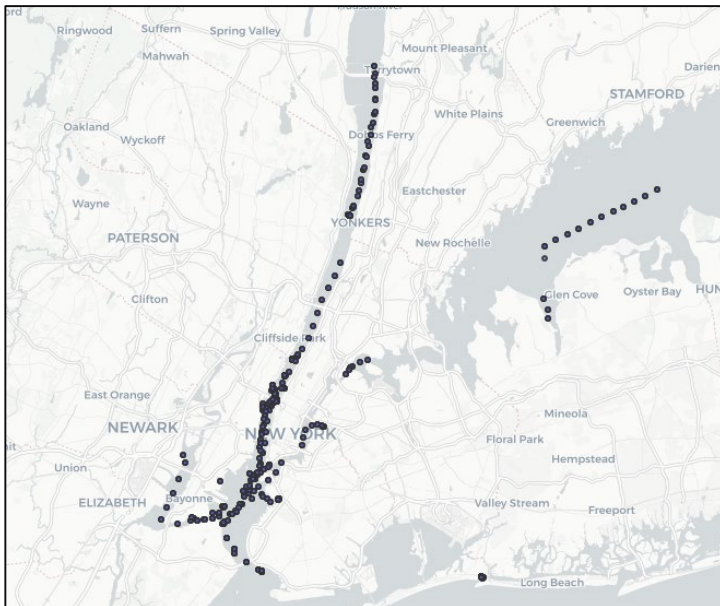
For all Vessels using
Emission Control Area
(ECA) Compliant
Distillate Fuels

Disatillate Marine Fuel HAP Profiles				
Pollutant	Basis	Fraction	Pollutant	Basis
1,3 Butadiene	VOC	0.001013	Ammonia	PM2.5
2,2,4- Trimethylpentane	VOC	0.00712	Antimony	PM2.5
Acenaphthene	VOC	5.087E-05	Arsenic	PM2.5
Acenaphthylene	VOC	0.0001178	Benz(a)anthracene	PM2.5
Acetaldehyde	VOC	0.0097826	Benzo[a]Pyrene	PM2.5
Acrolein	VOC	0.0018478	Benzo[b]Fluoranthene	PM2.5
Anthracene	VOC	0.0003436	Benzo[k]Fluoranthene	PM2.5
Benzene	VOC	0.0047391	Benzo[ghi]perylene	PM2.5
Ethyl Benzene	VOC	0.0004391	Cadmium	PM2.5
Fuorene	VOC	0.0001642	Chrysene	PM2.5
Formaldehyde	VOC	0.0426957	Chromium	PM2.5
Naphthalene	VOC	0.0313043	Chromium VI	PM2.5
Hexane	VOC	0.00279	Dibenz[a,h]anthracene	PM2.5
Phenanthrene	VOC	0.001356	Fluoranthene	PM2.5
Propionaldehyde	VOC	0.0015174	Indeno[1,2,3-c,d]Pyrene	PM2.5
Toluene	VOC	0.0020348	Lead	PM2.5
m&p Xylene	VOC	0.0014217	Manganese	PM2.5
o-Xylene	VOC	0.000513	Mercury	PM2.5
			Nickel	PM2.5
			PCB	PM2.5
			Pyrene	PM2.5
			Selenium	PM2.5
			Pyrene	PM2.5
			Zinc	PM2.5
			Zinc	PM2.5

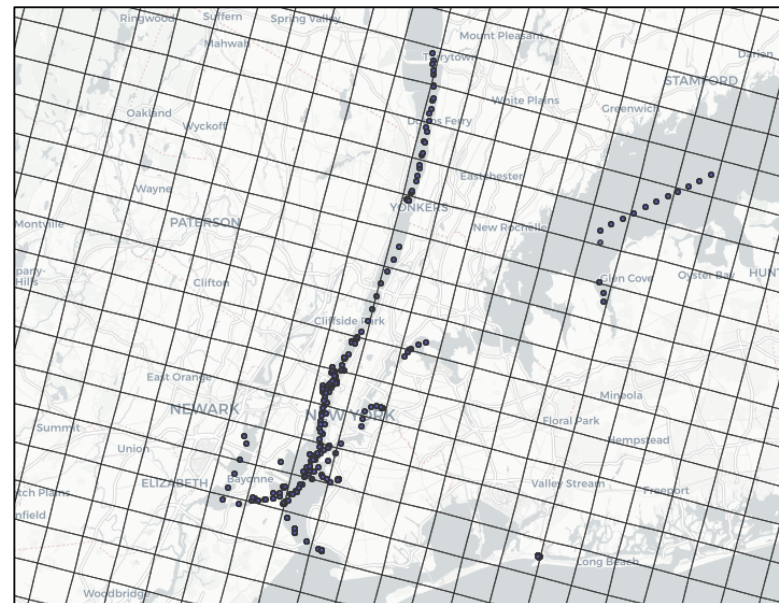
Rasterization

C1 & C2 East Coast Tug Emissions

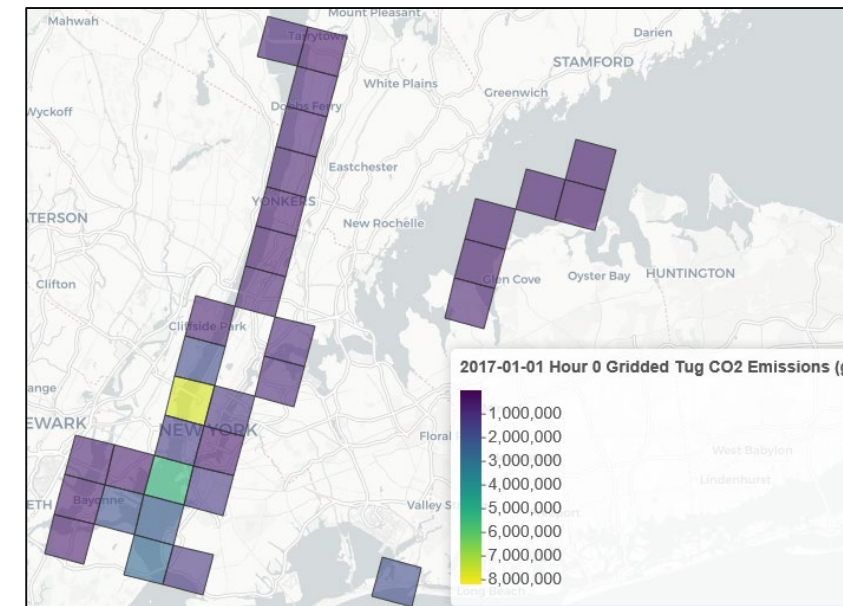
Allocate AIS Interval Emissions to Message Location Following the Activity Interval



Overlay Points with Desired Raster Grid and Projection

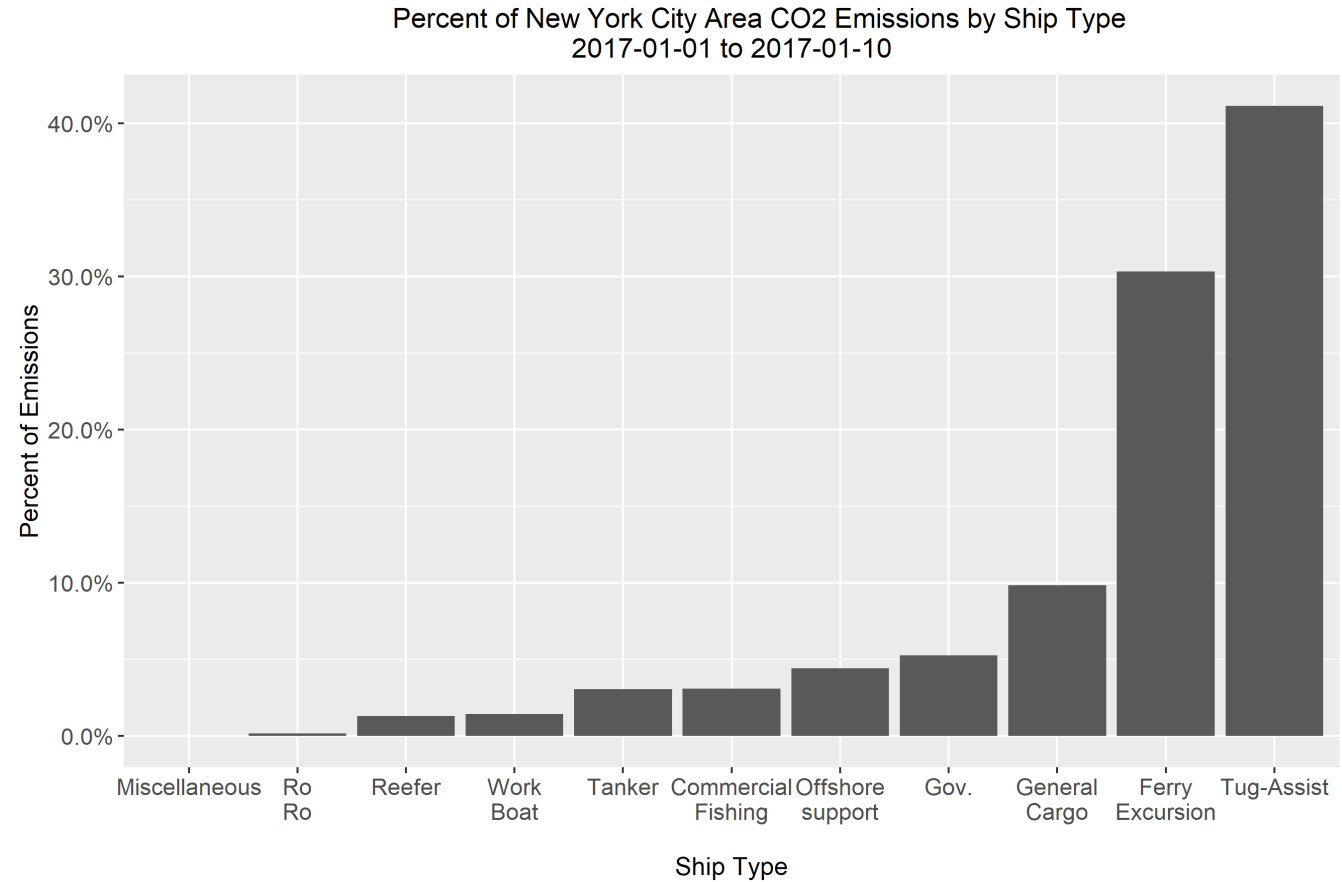
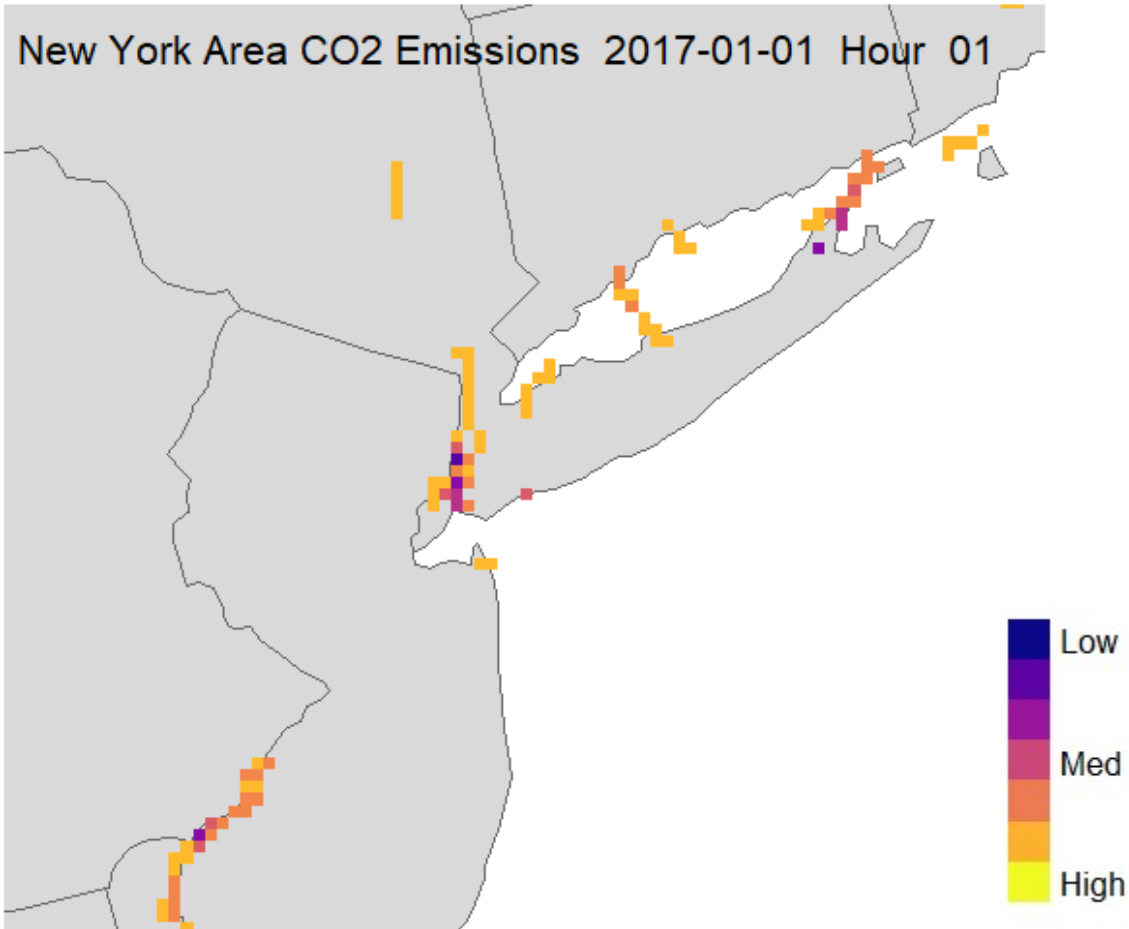


Sum Up Emissions within Each Grid Cell



Rasterization

C1 & C2 East Coast Tug Emissions

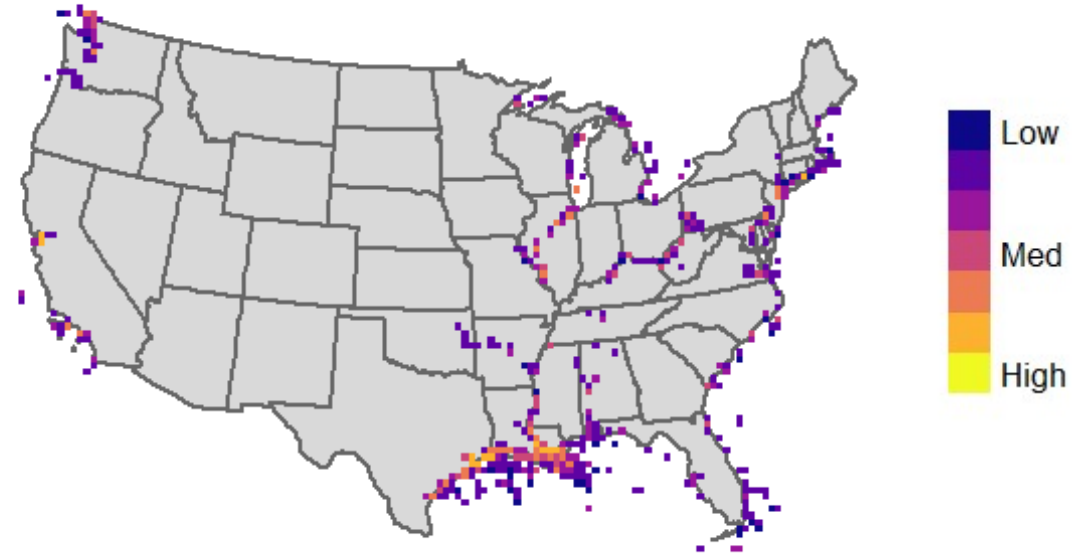
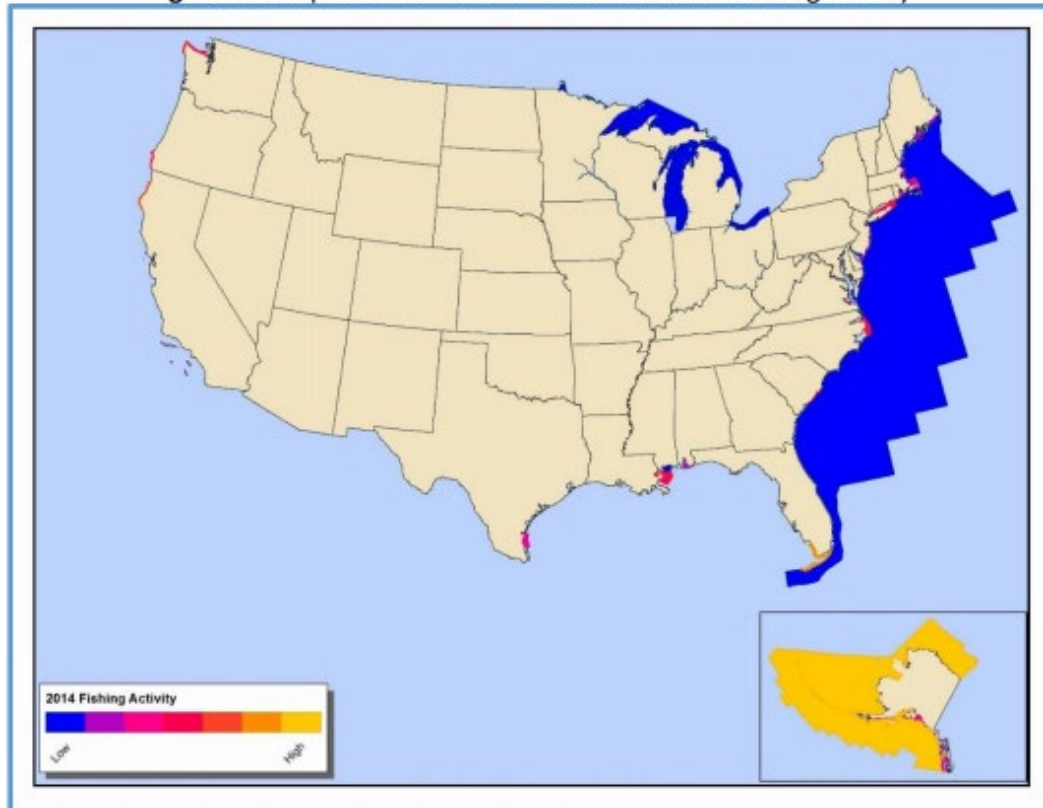


Commercial Fishing Emissions

2014 vs. 2017

Fishing CO2 Emissions 2017-01-01 Hour 01

Figure 4-19: Spatial allocation of 2014 commercial fishing activity



Acknowledgments

❖ Richard Billings, Heather Perez, Roger Chang, Lindsay Dayton – ERG

❖ Michael Aldridge, Sarah Roberts, Laurel Driver, Alison Eyth - EPA

