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COMPLIANCE MONITORING - RECOMMENDATIONS

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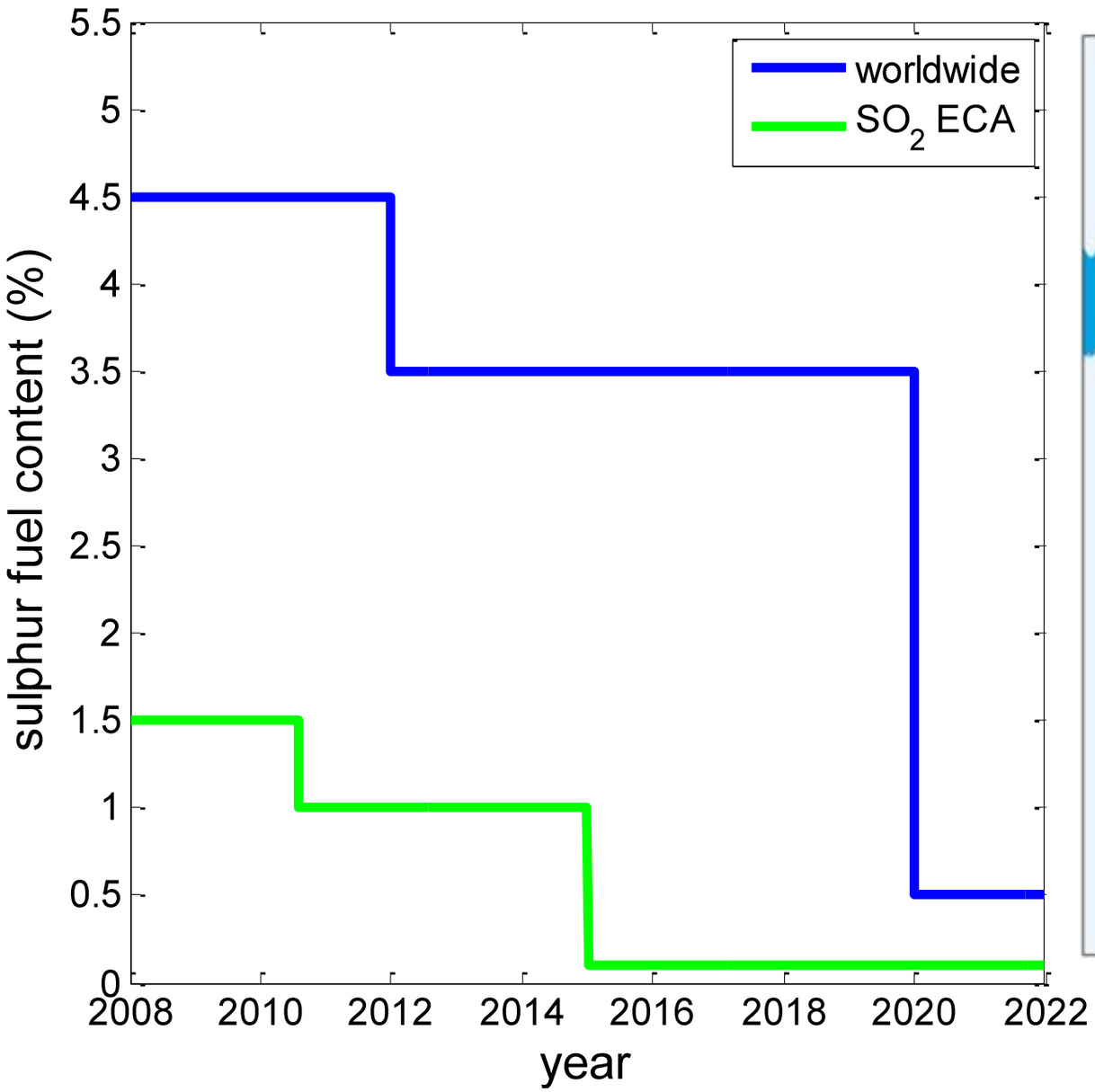
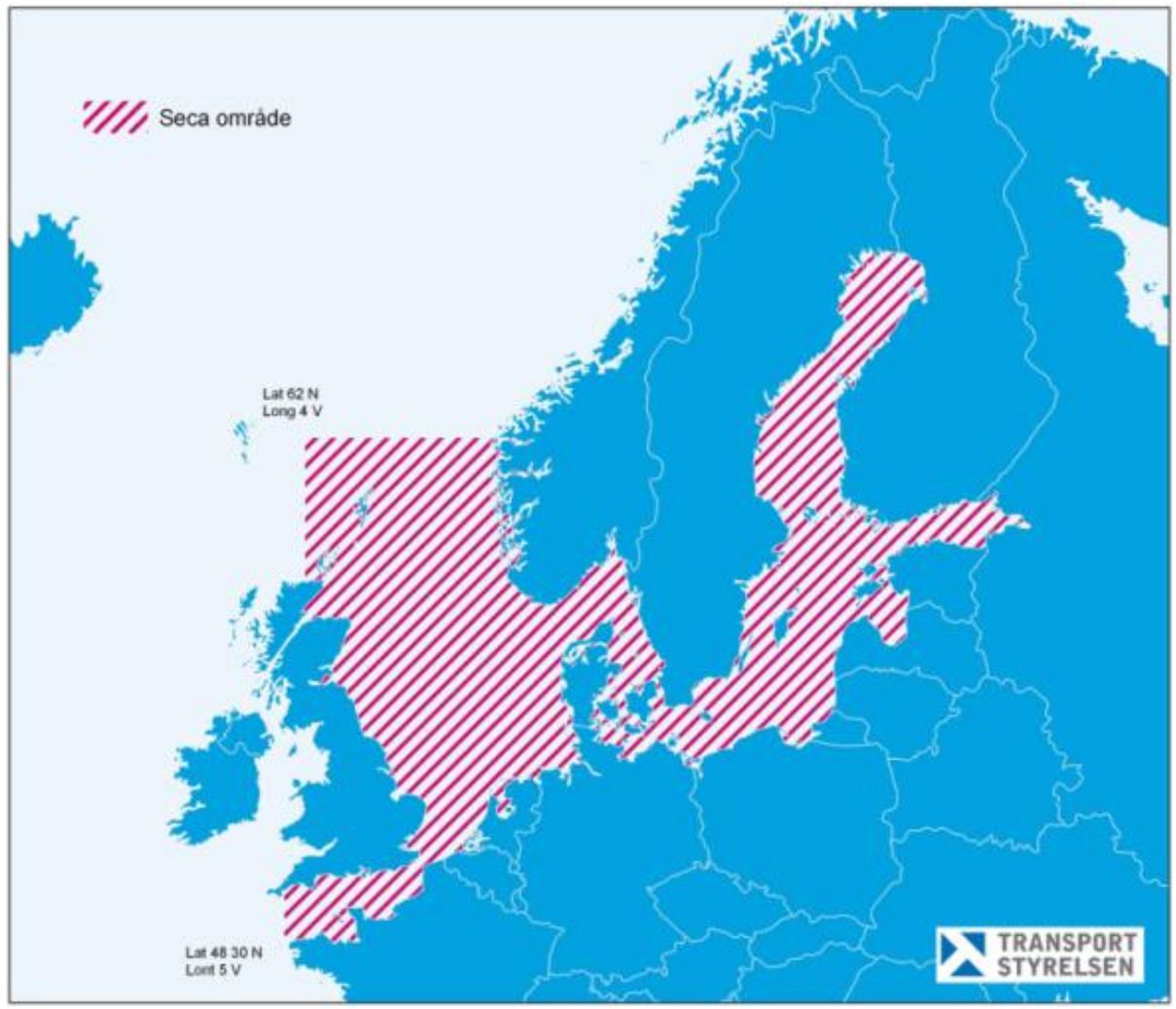
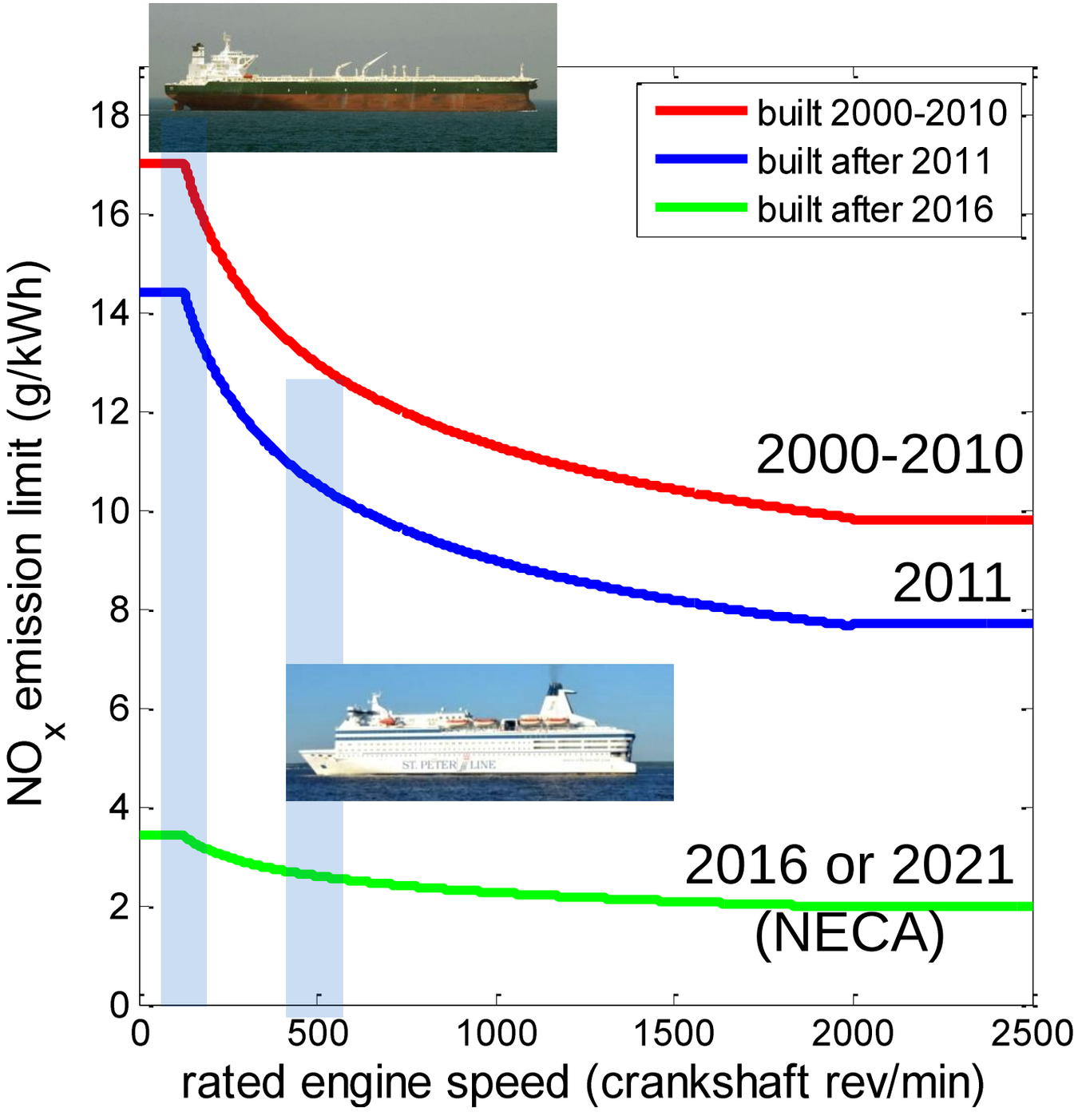
Limit of **sulfur fuel content** for ships (IMO, MARPOL Annex VI) and EU directive 2012/33/EU





Sulfur Emission Control Area

NOx emission limits for ships (IMO, MARPOL Annex VI) and EU directive 2012/33/EU



The problem

- Ships emit large quantities of air pollutants and it is necessary to reduce these to improve air quality.
- Most countries have ratified the IMO Marpol annex VI protocol. and EU has adopted directive 2012/33/EU. This will lower the SECA SO2 emissions by an order of magnitude in 2015.
- In the SECAs there will be extra cost for ship transport (50-70%), i.e. 20-30 kEuros for ships traveling on the Baltic sea. *There will hence be considerable economic incentive not to comply with SECA regulation.*
- Today the fuel of the ships is controlled by random checks of bunker delivery notes, fuel logs and occasional fuel sample analyses in harbors. This is time consuming and only few ships are being controlled. E,g in 2011 32 ships were detained in EU.
- There is no available technique able to control what fuel is used in the open sea and in general it is considered easy to tamper with the usage of fuel, especially since ships are using several tanks, often with different fuel.

- The new action plan for shipping by the Swedish government underlines that it is *important to carrry out compliance monitoring in order to promote fair competition between shipping companies*,

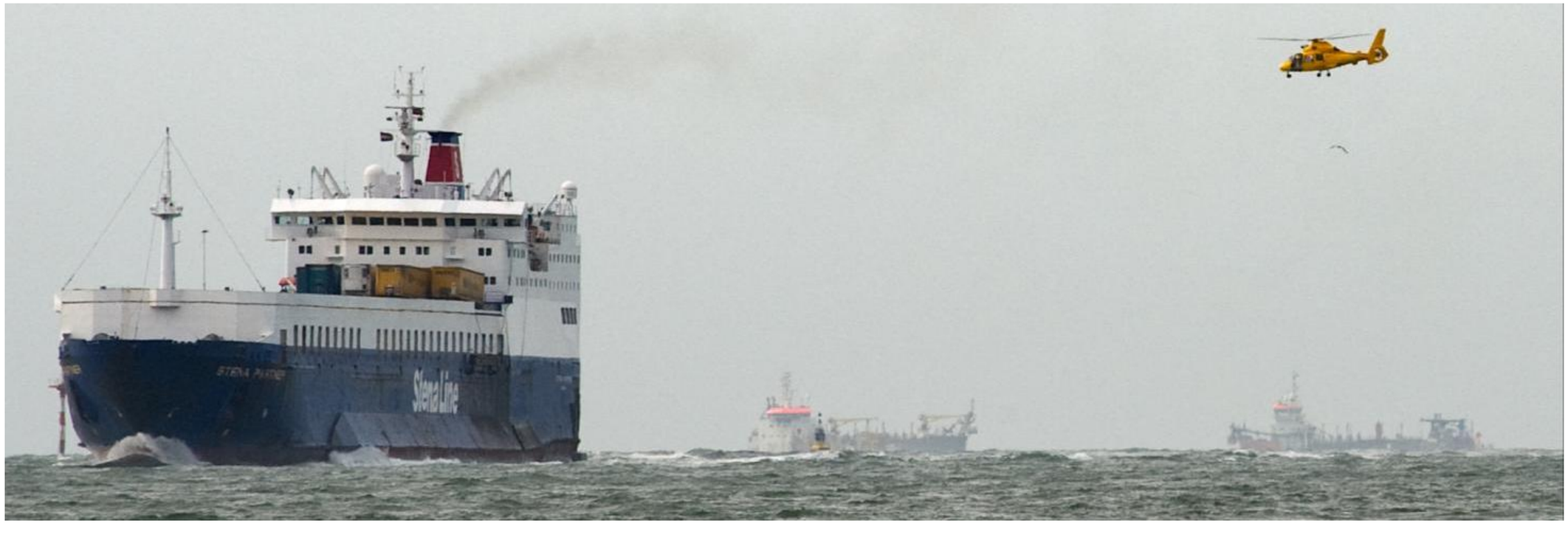
Research Activities

- In the Swedish project **IGPS,** running since 2006**,** a measurement system for airborne and groundbased compliance monitoring of individual ships has been developed
- EU- JRC did an intercomparison study in Rotterdam 2009 of various measurement techniques for compliance monitoring
- *FMI has equipped an airplan (skyvan), with the possibility to measure ship emissions .*
- *BSH-Hamburg has started carrying out ship emissions measurements from an island outside the Kiel canal*
- *Denmark will carry out measurements on the Stora Bält bridge*
- *The European standardisation institutes has a call through Euramet to develop ship emission measurement techniques*

Rotterdam campaign 2009

DIAL
DOAS
Sniffer
UV camera

Berg, AMT 2012
Alfoldy, AMT, 2013
Balzani AMT 2013

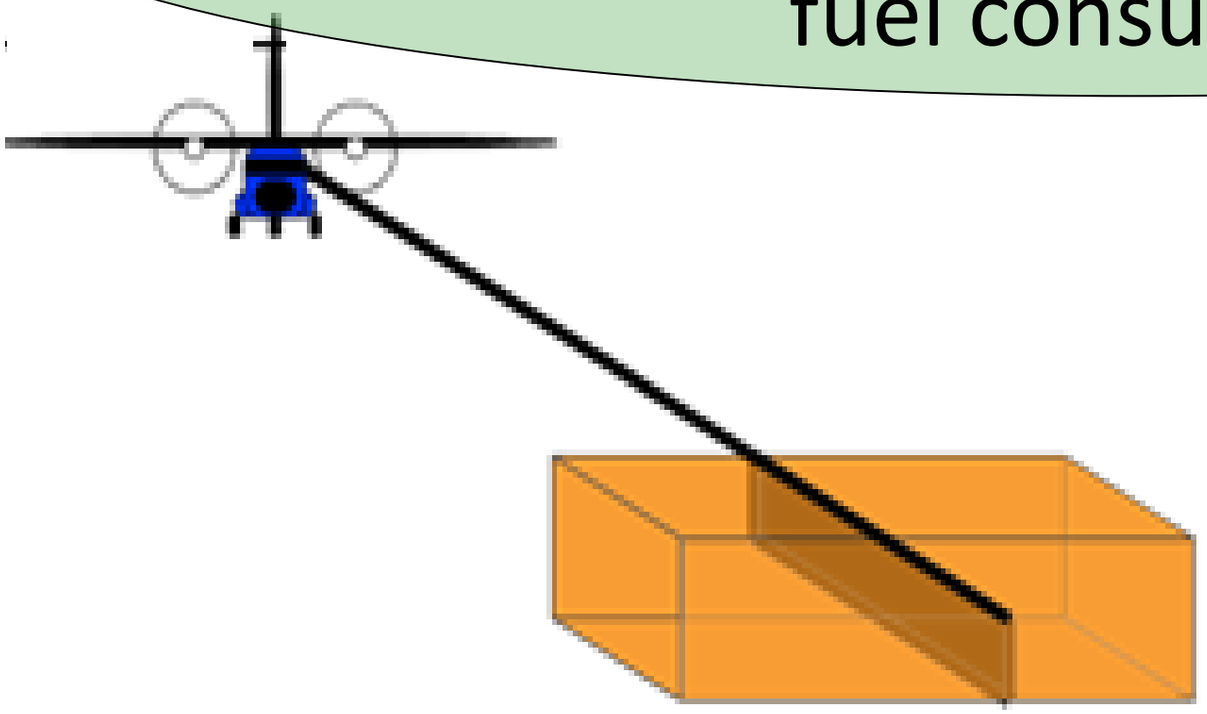


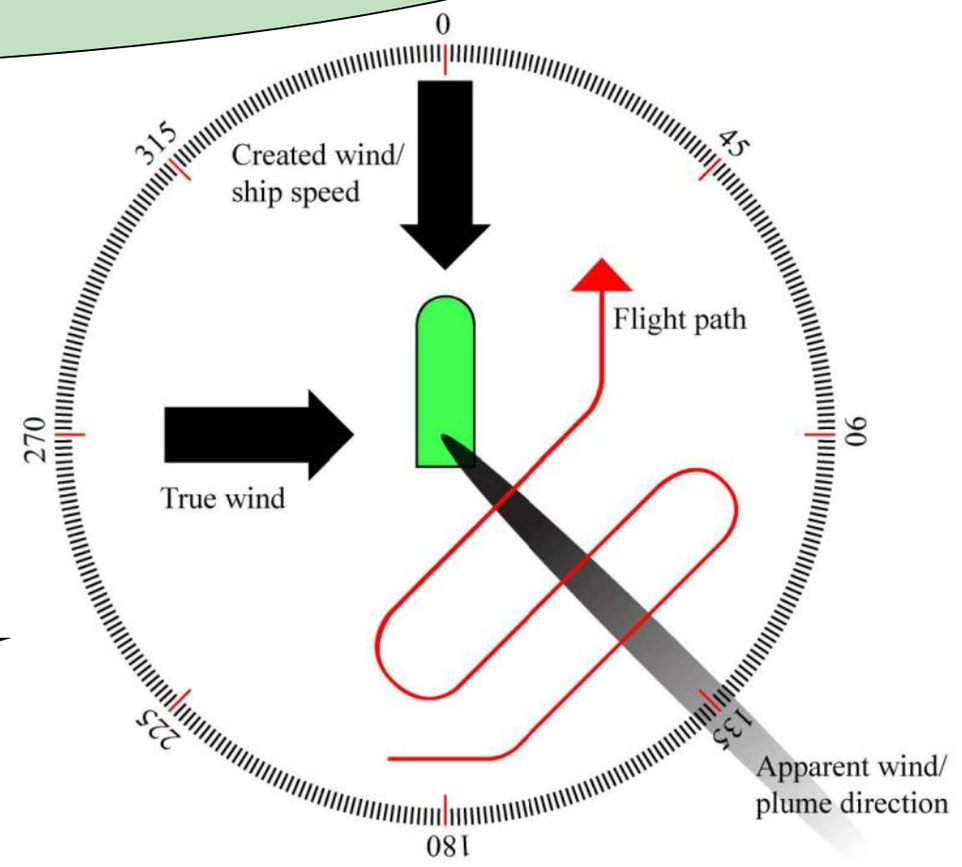
IGPS(Identification of Gross Polluting Ships)

- A measurement system has been developed for **compliance monitoring of individual ships** with respect to stack emissions of SO_2, NO_x and particulates.
- The system has been tested from various airborne platforms in campaigns on the Baltic Sea and North sea for more than 200 ships with 20 % estimated accuracy. In particular two ship emission campaigns have been carried out in Sankt Petersburg during 2011 and 2012 within BSR Innoship.
- A system is presently being certified for permanent use in a Danish Navajo Piper.
- Measurements are carried out from a fixed station in Göteborg harbor at Älvsborgsfästning. More than 2000 ship measurments
- The IGPS project is explicitly mentioned in the Swedish governments new action plan for shipping

IGPS surveillance method

Fly over ships and conduct optical flux measurement (**g/s**), (altitude 300 – 600 m) and model fuel consumption

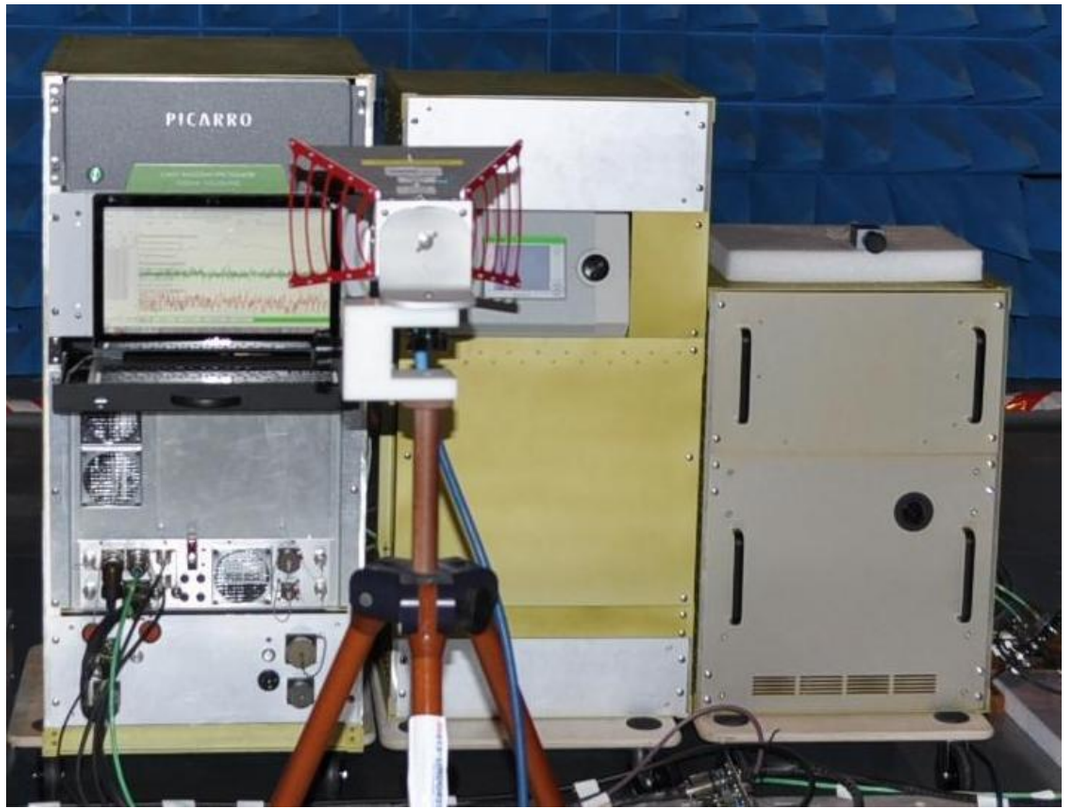


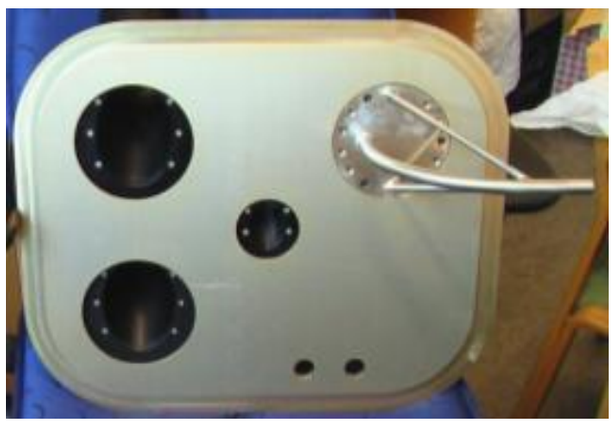


For high emitters fly through the fluegases and conduct sniffer measurements (altitude 50-300 m) to obtain emission factors (**g/kg_{fuel}**)

IGPS system

species	description	method	sample rate
CO_2,CH_4,H_2O	Picarro G2301-m	Cavity Ring-Down Spectroscopy	2 Hz
SO_2	Thermo 43i-TLE	Fluorescence (modified)	1 Hz
NO_x	Thermo 42i-TL	Chemiluminescence (modified)	1 Hz
PM	TSI EEPS	Electrostatic mobility	10 Hz
SO2/NO2	Andor 303	Passive optical (DOAS)	1 Hz

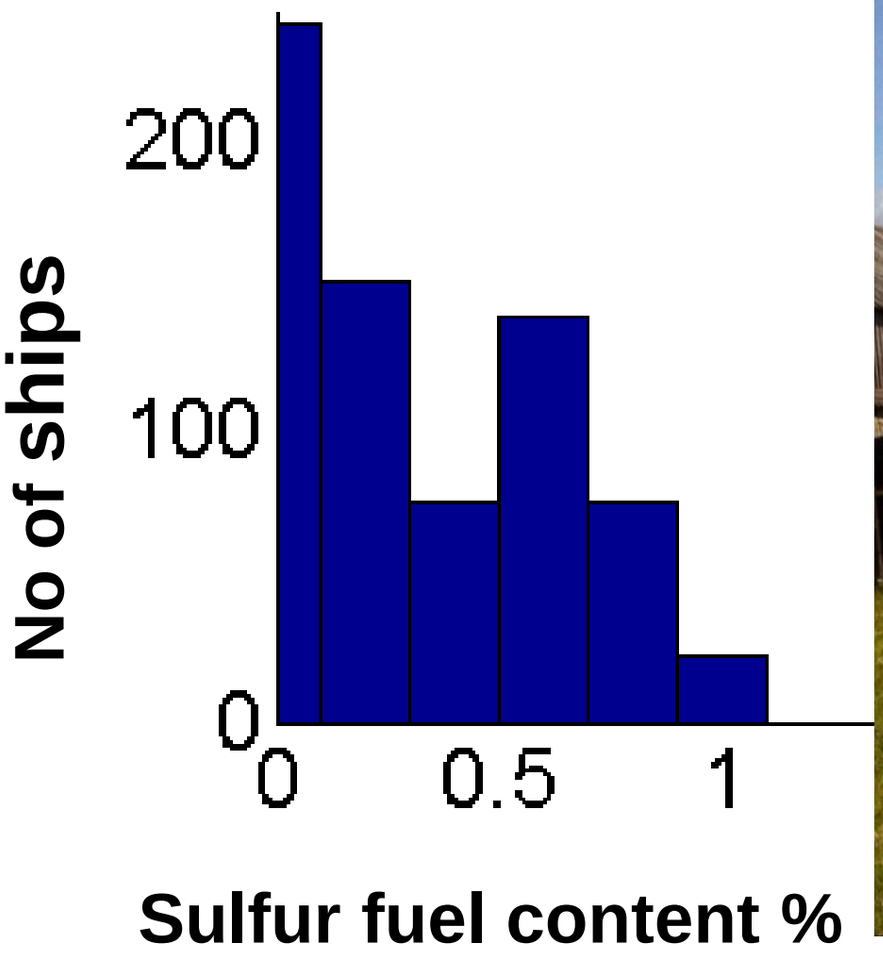




The IGPS system includes an AIS reciever and software to plot the locations of the ships and airplane/helicopter. Here is shown ship measurements within BSR-Innoship from a MI-8 helicopter in Neva bay outside Sankt Petersburg.

Stationary system

An autonomous IGPS-system with real time identification of gross polluting ships has been built into a water tight box. The system calculates the sulfur fuel content of individual ships from SO2/CO2 measurements in the exhaust plumes. It has been in continuous operation since February 2012 in Göteborg. More than 2000 ship measurents.

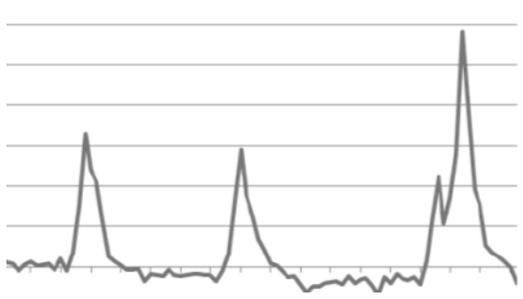


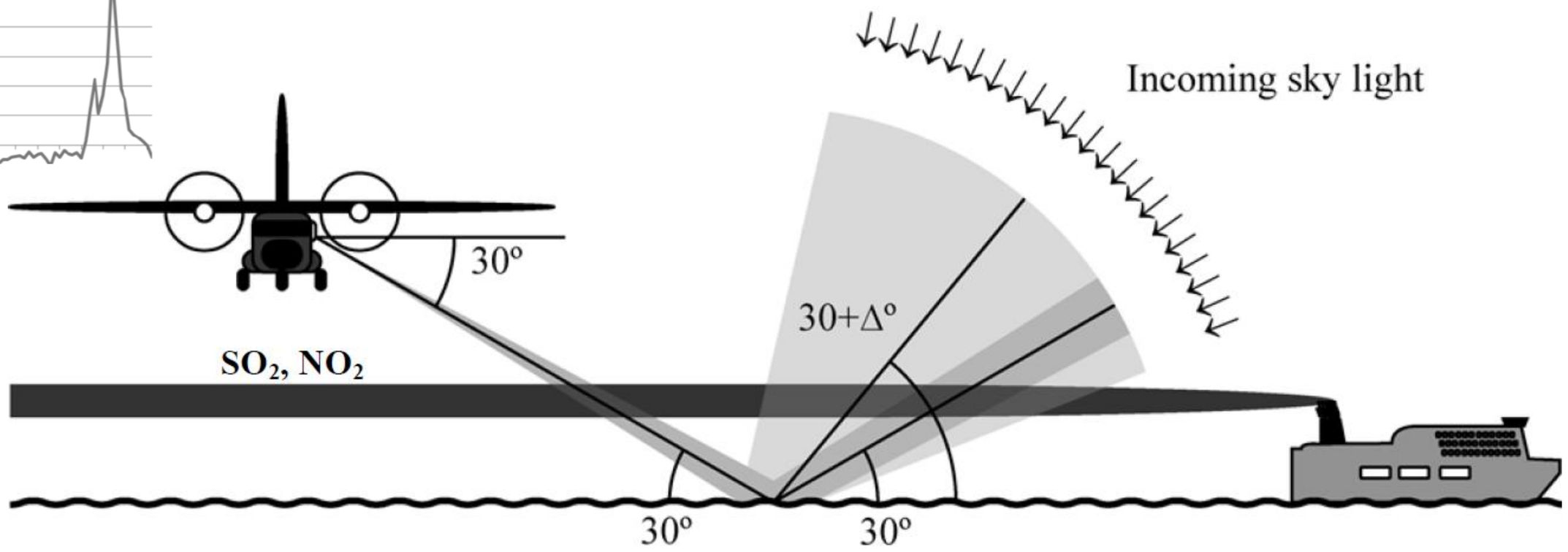
Optical system

An optical sensor measures ship emissions of SO_2 and NO_2 in the **unit g/s** (Berg and Mellqvist, Atmos. Meas. Tech.,, 2012) from 250 m altitude.

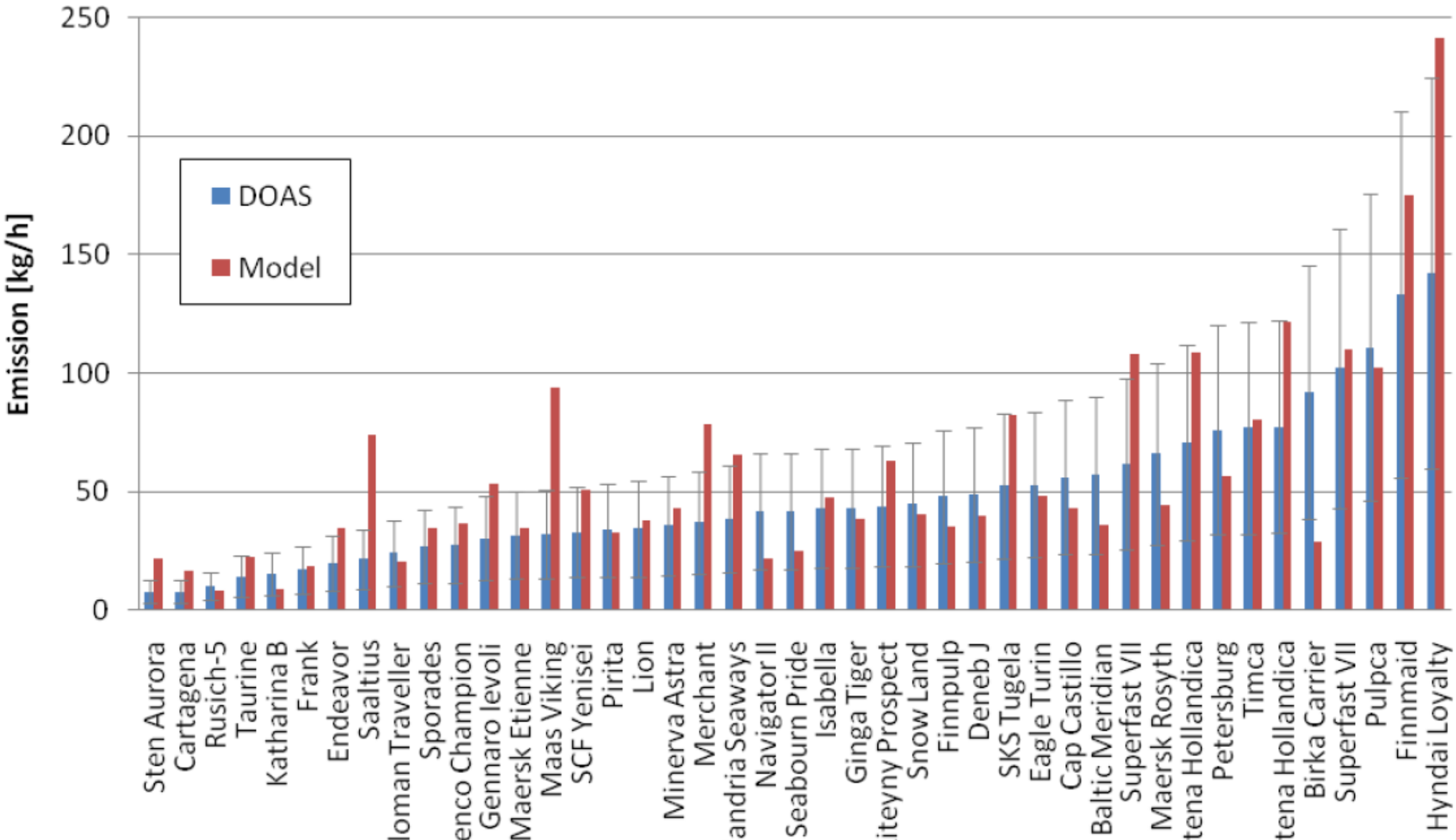
This sensor is used as a first alert system, distinguishing high sulfur (1%) from low sulfur ships (0.1%) remotely,

The optical system is complemented by ship specific CO2 emissions by the STEAM model (FMI) (Jalkanen) to obtain sulfur fuel content





Optical airborne emission measurements on the Baltic and North Sea (Berg AMT 2012). In addition (data from a ship emission model (STEAM) are shown



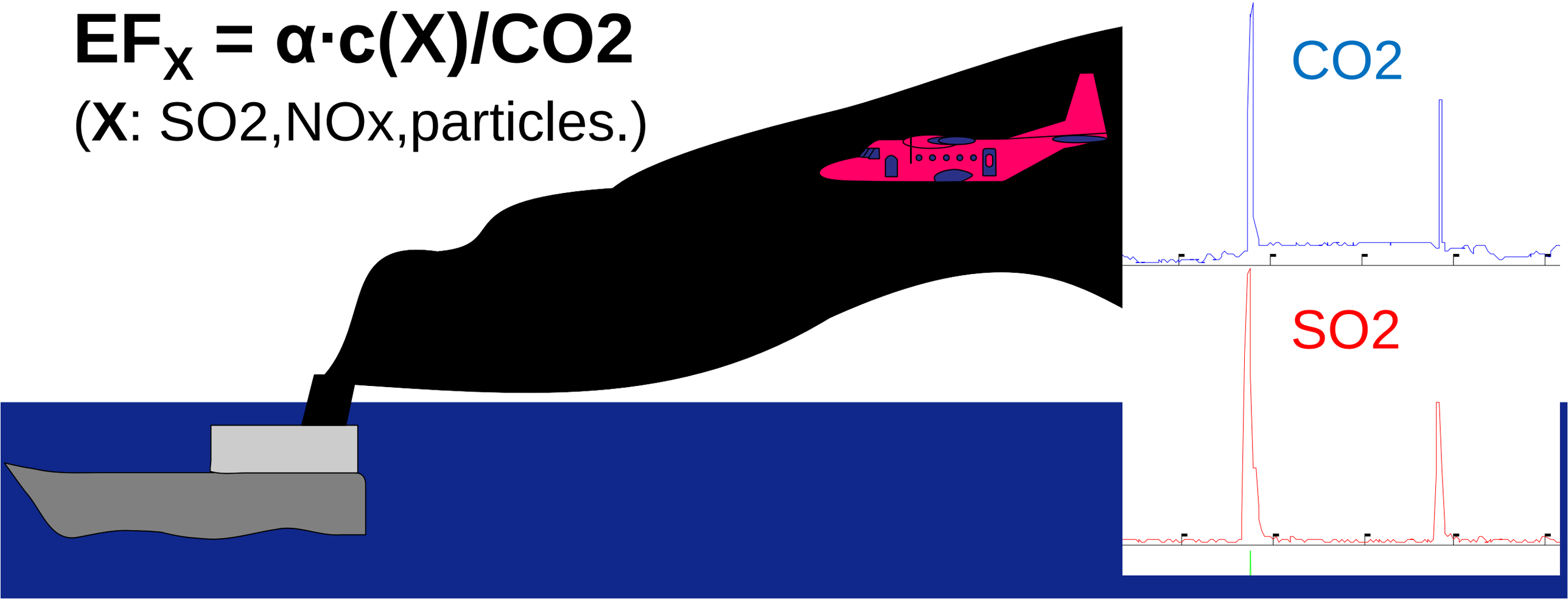
Sniffer measurement

Emission factors in **g/kg$_{fuel}$** are obtained by measuring the ratio of the pollutant **X** versus the concentration of CO_2, downwind of the plume.

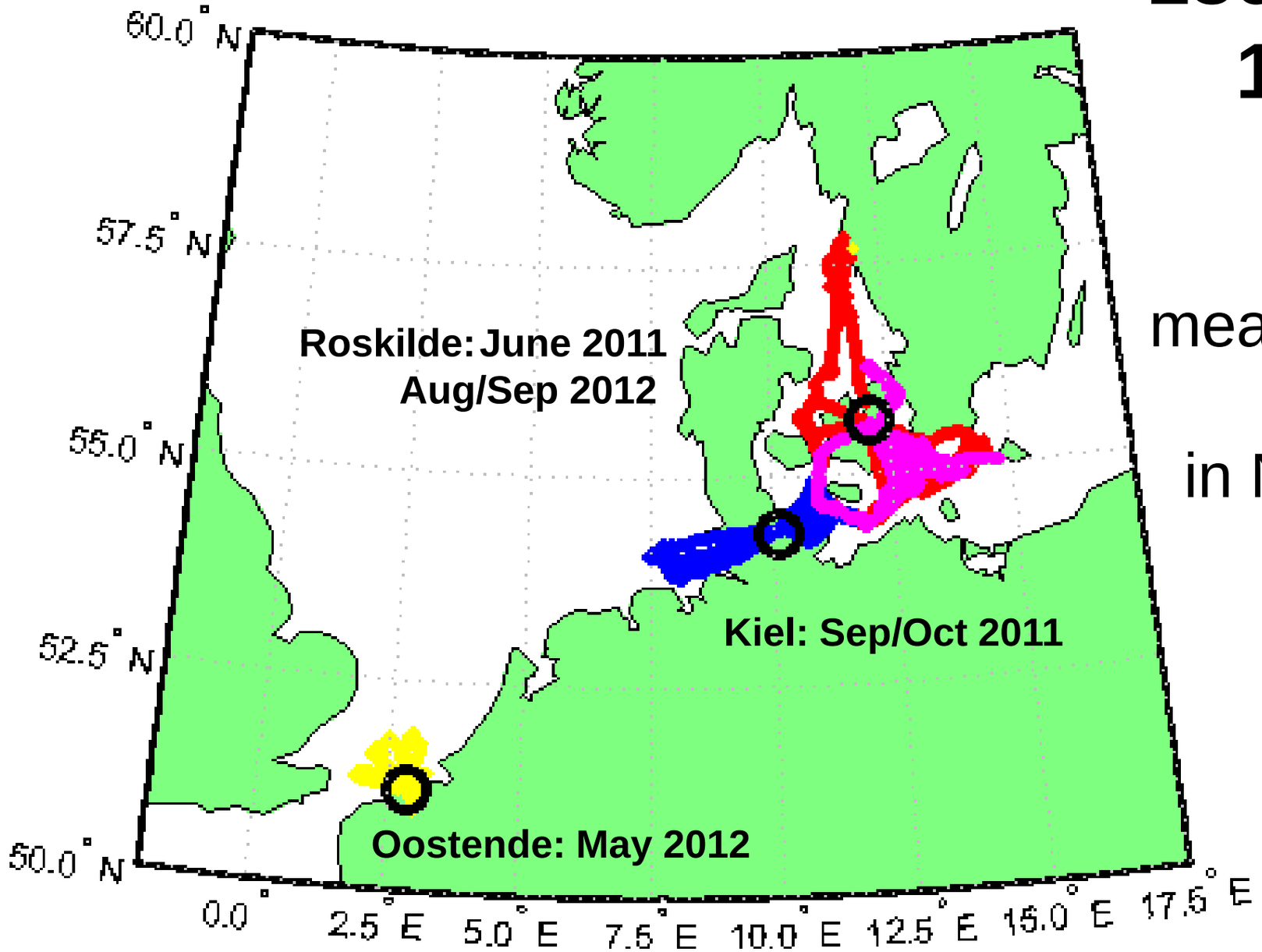
Accuracy 15-20%

$EF_X = \alpha \cdot c(X)/CO2$

(**X**: SO2,NOx,particles.)



Ship measurements Baltic and North sea

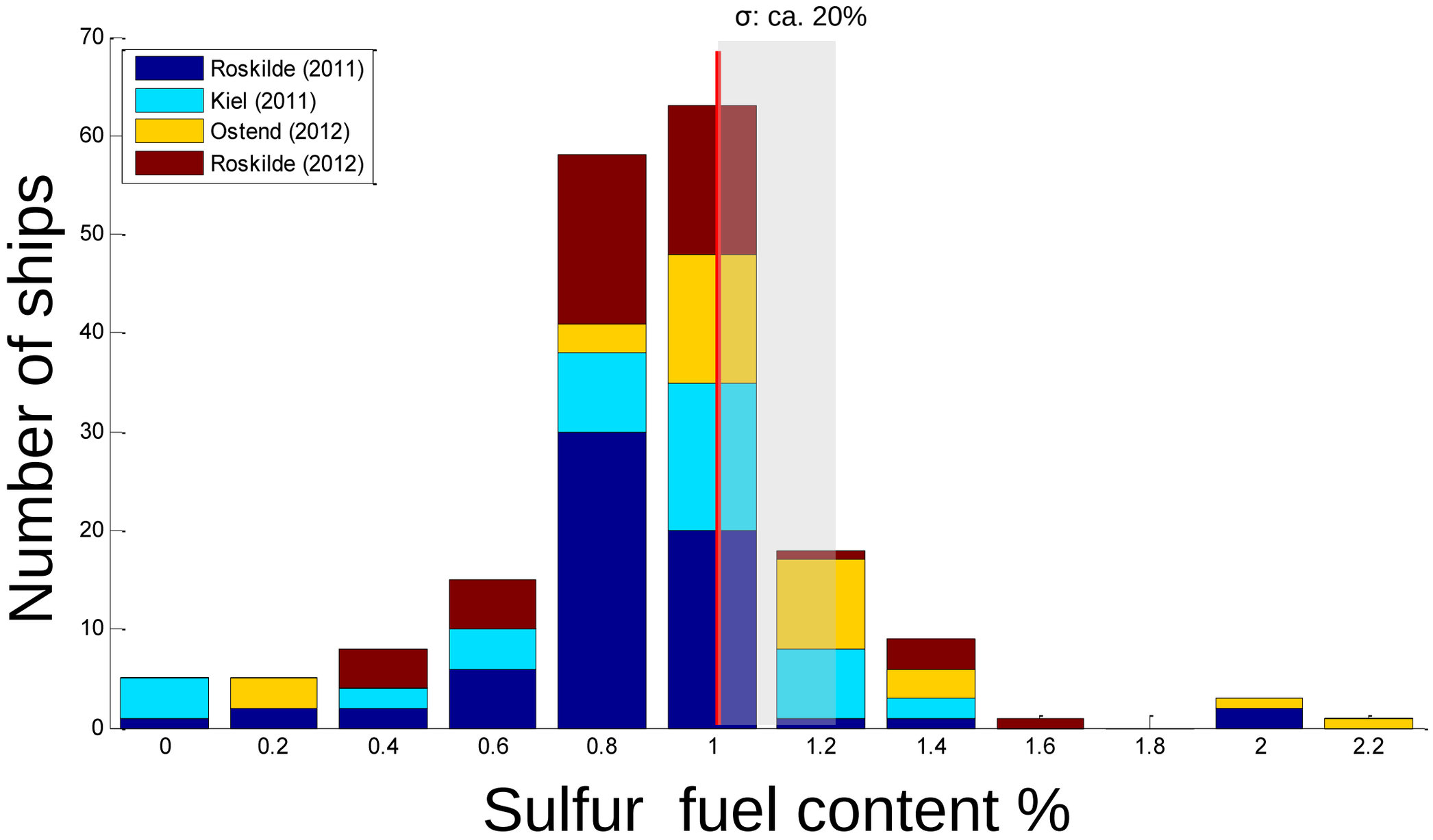


186 measured plumes of **162** different ships

approximately **3** measurements per plume

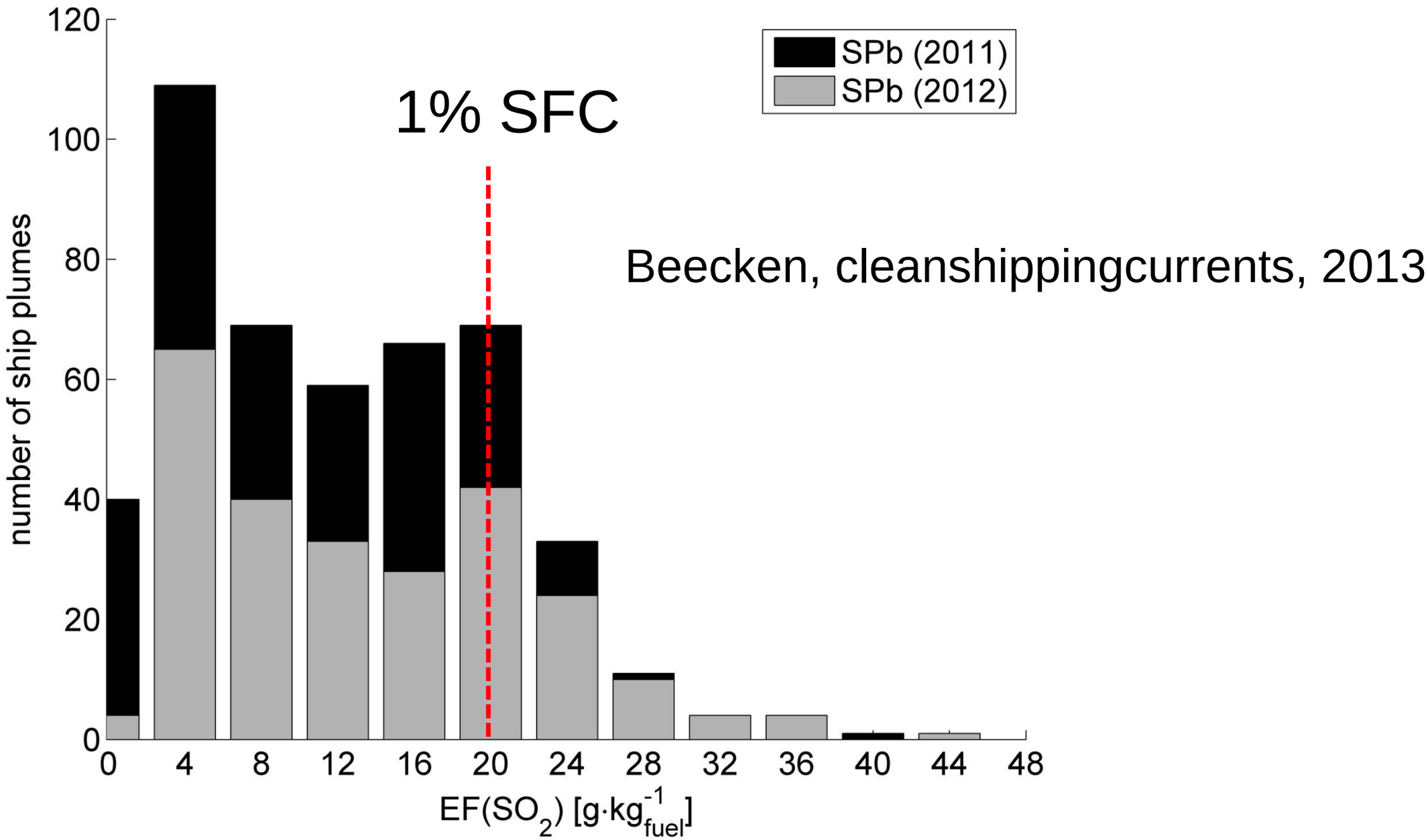
in North and Baltic Sea

Sulfur content histogram obtained by airborne measurement of 162 ships in the Baltic and North sea 2011/2012 (Beecken AMT 2013)



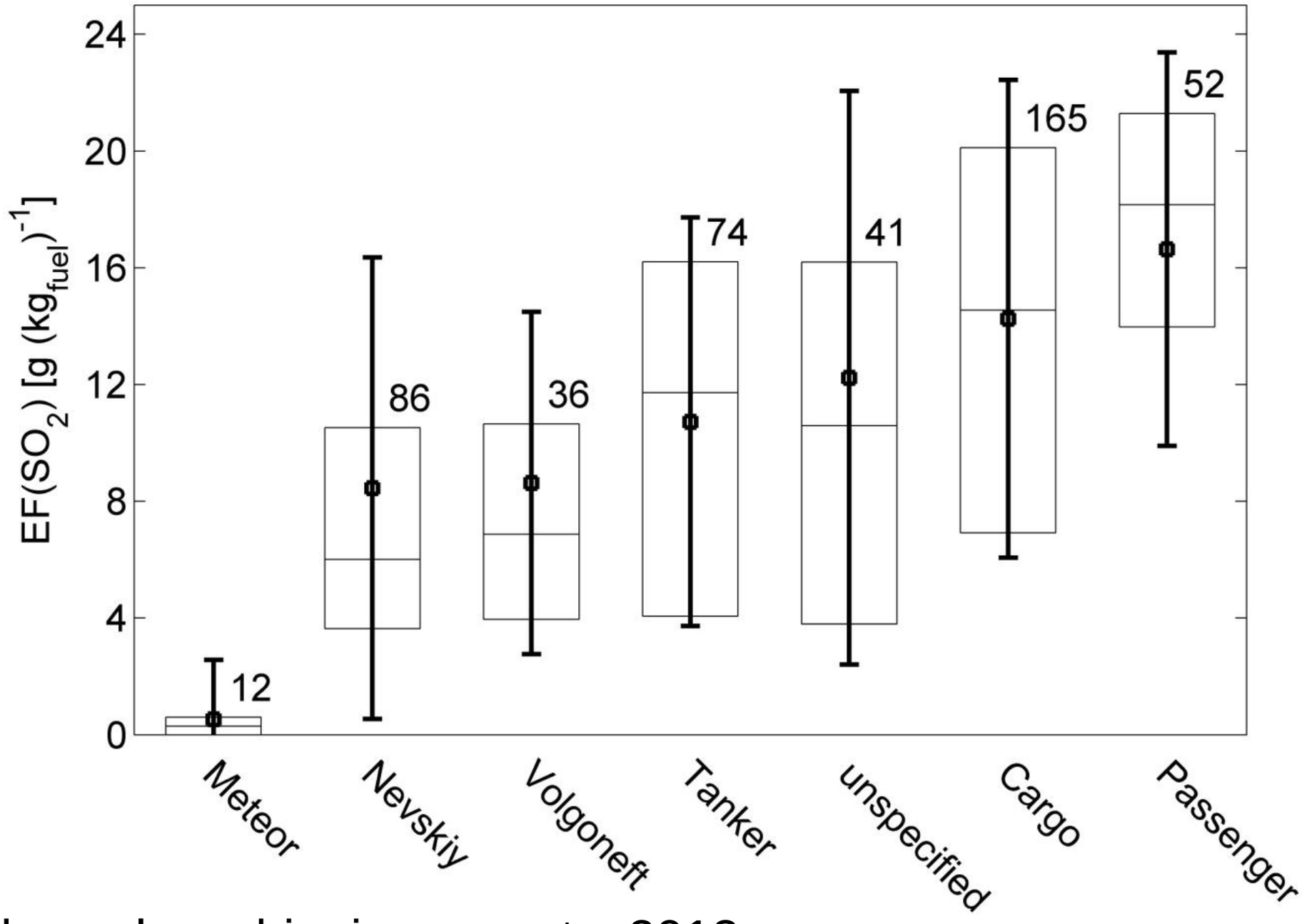
Compliance: ca. 90%

Emission factors of SO2 from Sankt Petersburg



Beecken, cleanshippingcurrents, 2013

Emission factors Sankt Petersburg



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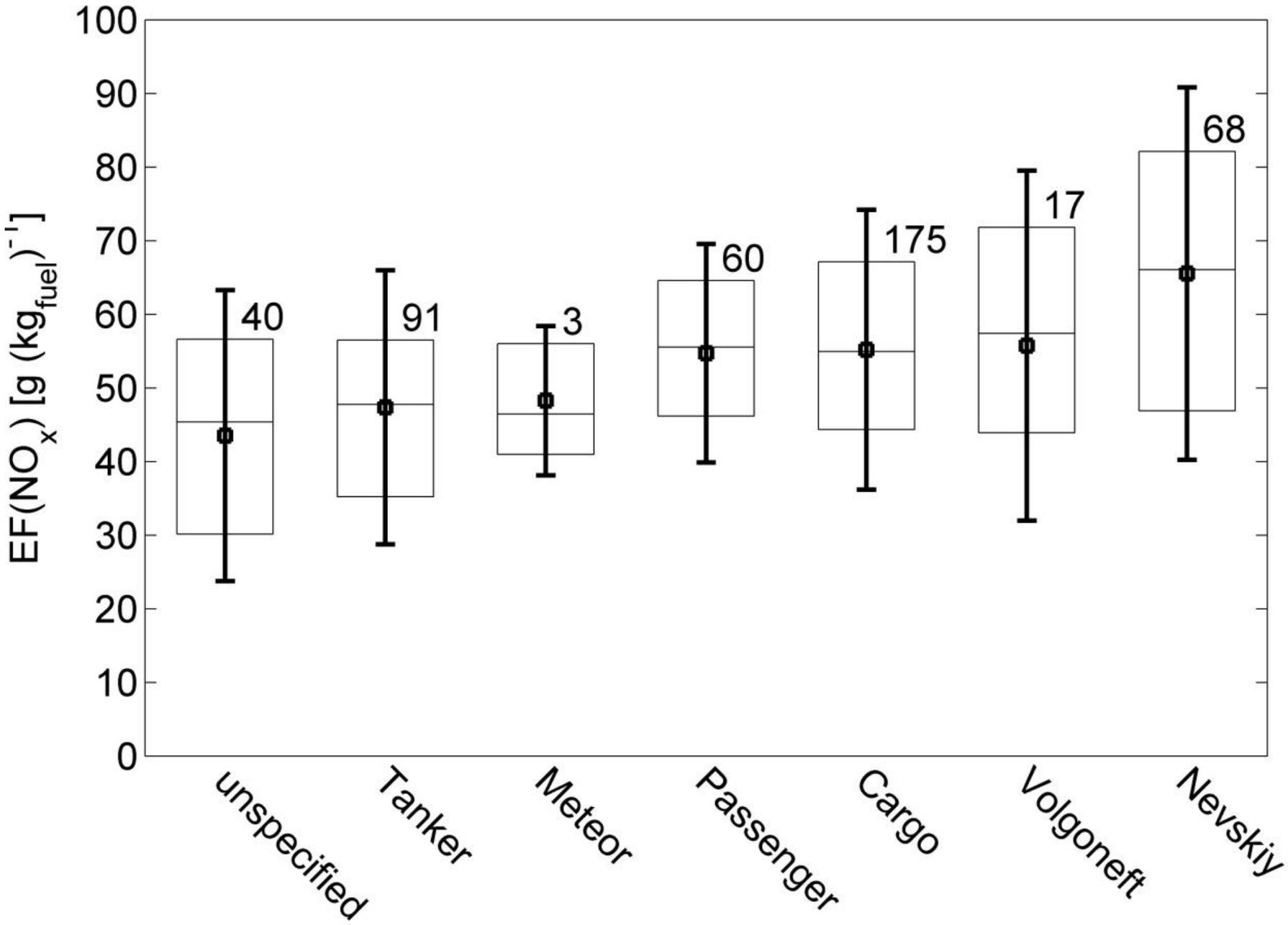

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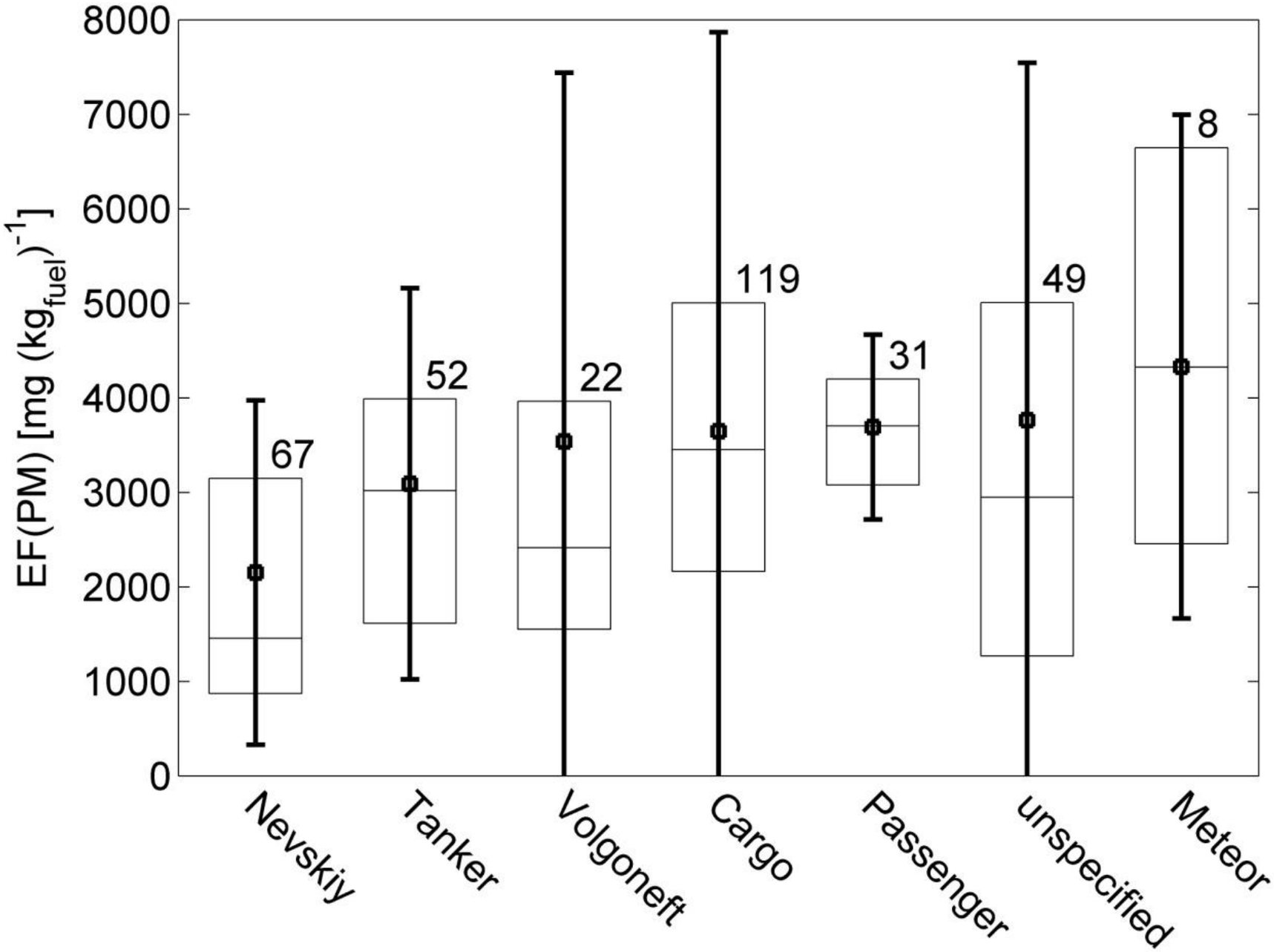

Beecken, cleanshippingcurrents, 2013

Recommendations

Compliance monitoring of ships is needed to make sure that the SECA rules are implemented in practice and to get fair competition

Research activities shows that sniffer measurements combined with optical methods works in practice and that they can be carried out from airplanes, ships and stationary sites close to shipping lanes with adequate accuracy

Funding is needed to implement measurement activities.