Trends of shipping impact to particulate matter in two Adriatic port-cities

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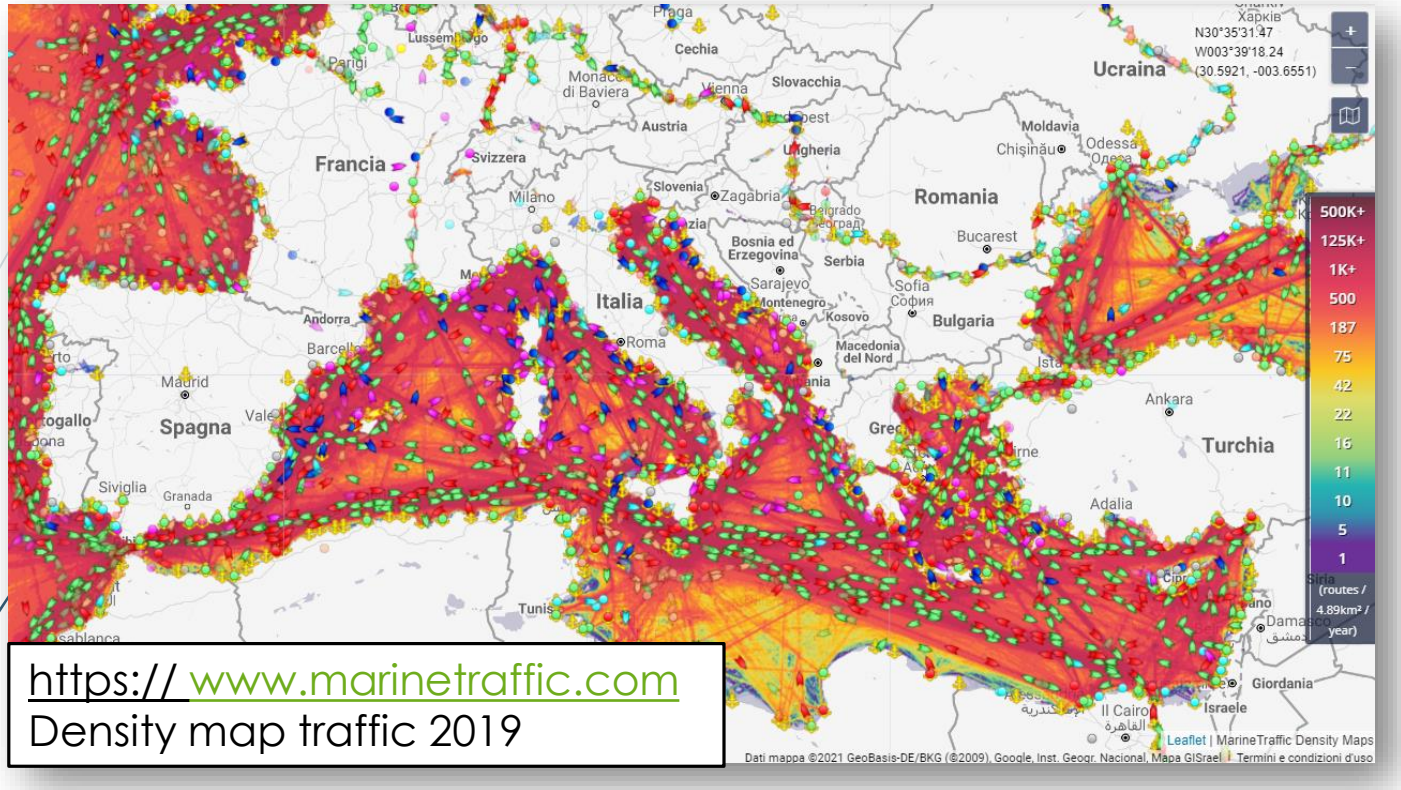
Introduction - shipping



https:// www.marinetraffic.com
Density map traffic 2019

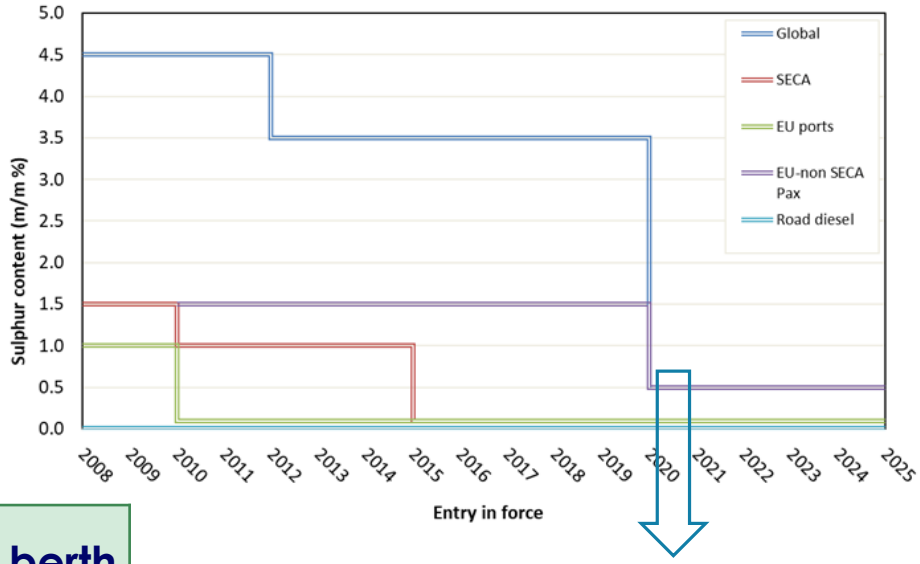
Relevant source of CO_2, NO_X, SO_2 and PM, at different scales
Expected annual growth rate of 3.5% over 2019–2024 (UNCTAD, 2019)
Reduction strategies of sulphur and nitrogen oxides emissions (i.e., Emission Control Areas, IMO legislation, scrubbers, cold ironing)

Introduction – legislation

Global → Annex VI MARPOL Convention 73/78

Europe → Directive *2012/33/EU*

Local initiatives (Venice)

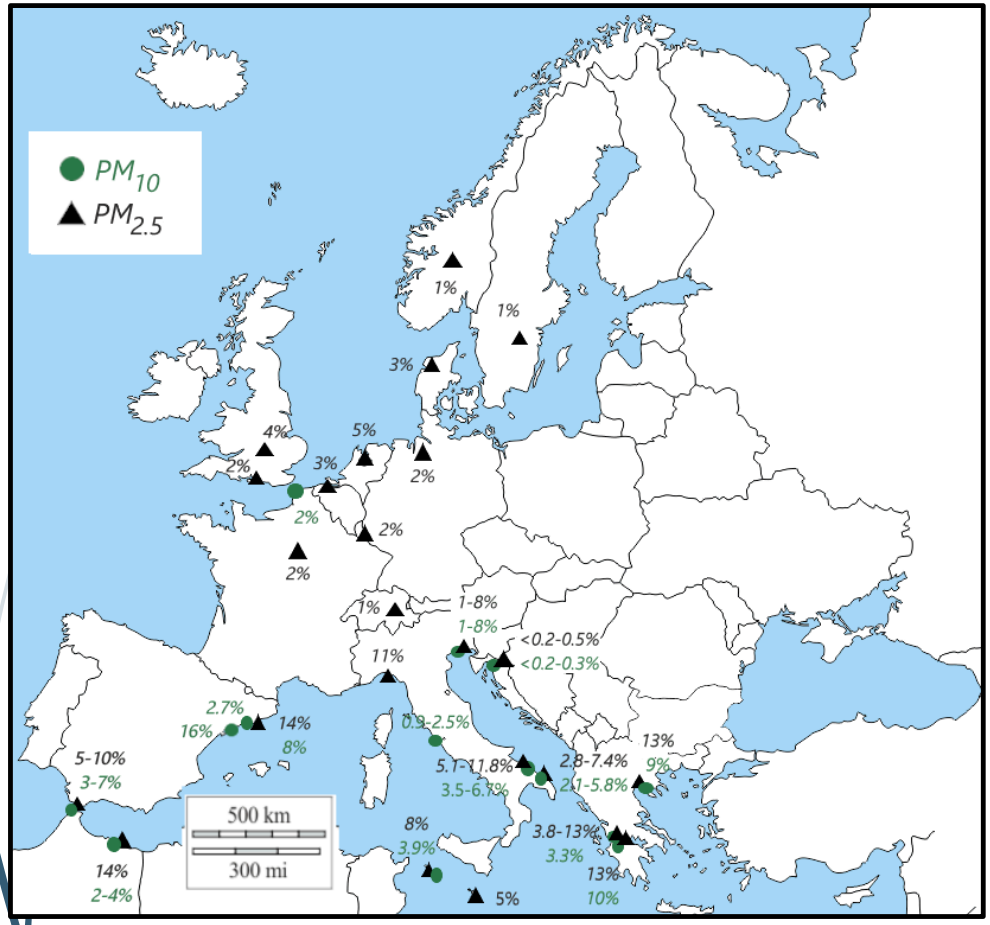


Year	Agreement	% S navigation	% S at berth
2007	Venice Blue Flag I	2.5% (+0.5%)	2.5% (+0.5%)
2008	Venice Blue Flag I	2.0% (+0.5%)	1.5% (+0.25%)
2009	Venice Blue Flag I	2.0%	1.5%
2013	Venice Blue Flag II	0.1%	0.1%

Other ratifications in 2015, 2016, 2017, 2018 and 2021 regarding extension of regulated area, public Information

Projections of effectiveness of «**Sulphur Cap 2020**»:
-34% premature deaths per year related to shipping
-**54%** childhood asthma morbidity
(Sofiev et al., 2018)

Shipping contribution to particulate matter



Contini and Merico, 2021

Ship traffic contribution ranges between 0.2% and 14% for $PM_{2.5}$ and between 0.2% and 10% for PM_{10} in Europe, with the largest impact in the Mediterranean area

Clear gradient between the Mediterranean Sea and northern Europe (ECAs)

Higher contribution to smaller particles (ship emissions dominated by fine particles and nanoparticles, especially in number)

Scarce and fragmentary evidences on extended-range size distribution

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Experimental campaigns in Venice

1.6 million cruise passengers in 2018
https://www.port.venice.it/


Sacca San Biagio, 2007, 2009 and 2012


Sacca Fisola, 2018

Interreg Italy - Croatia
European Regional Development Fund
EUROPEAN UNION

MED MARITIME INTEGRATED PROJECTS POSEIDON

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Experimental campaigns in Brindisi

637,340 passengers and 7.9 Mt of goods in 2018
http://www.adspmam.it/

MED MARITIME INTEGRATED PROJECTS POSEIDON

European Territorial Cooperation Programme
Greece - Italy
2007-2013
INVESTING IN OUR FUTURE
Co-funded by the European Union (ERDF) and by National Funds of Greece & Italy

CESAPO

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Sampling setup

Same instrumental setup at both sites:

Video camera for synchronization of ships movements (arrival and departure) with concentration data (resolution 30 s)

Ultrasonic anemometer and thermo-hygrometer for detection of meteorological parameters (100 Hz)

CPC* nanoparticles concentration (0.01–0.25 µm) 1 min resolution, with dried inlet

OPC* size distribution (0.25–31 µm) 1 min resolution

***CPC** Condensation Particle Counter
OPC Optical Particle Counter

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Statistical treatment for impact estimation

$$\varepsilon_C = \frac{(C_{DP} - C_{DSP})F_P}{C_D} = \frac{\Delta_C F_P}{C_D}$$

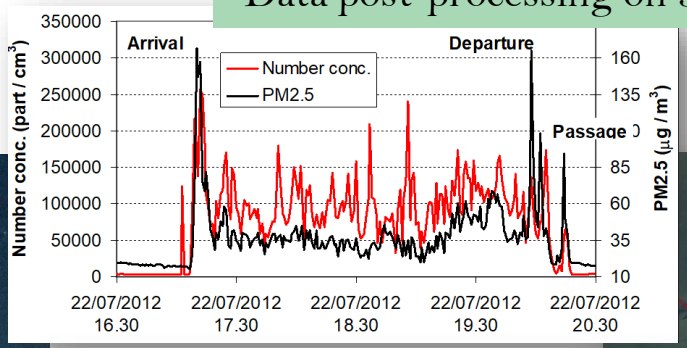
From: *Contini et al., J Environ Manag 92, 2119-2129, 2011*

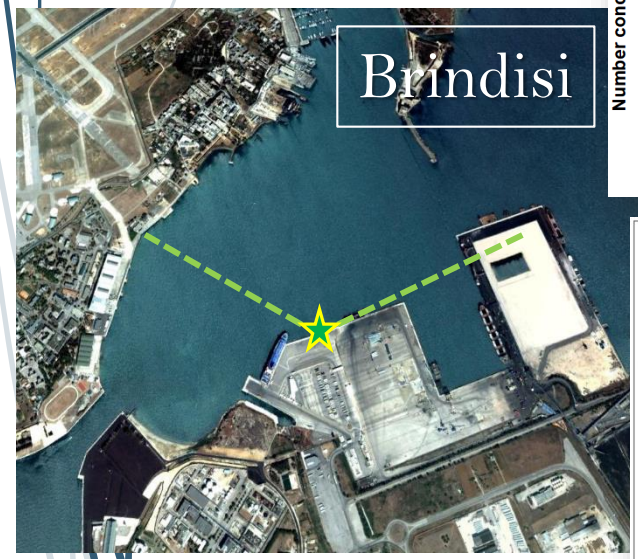
Δ_c= difference of average concentration during ship passages and with no ships

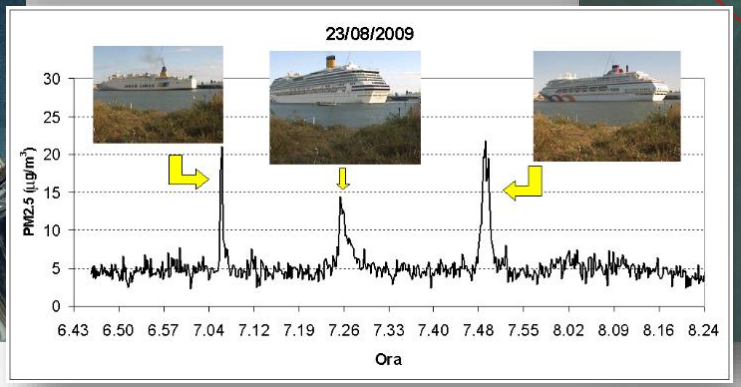
F_P= fraction of cases influenced by ships

C_D= average concentrations when the site is downwind

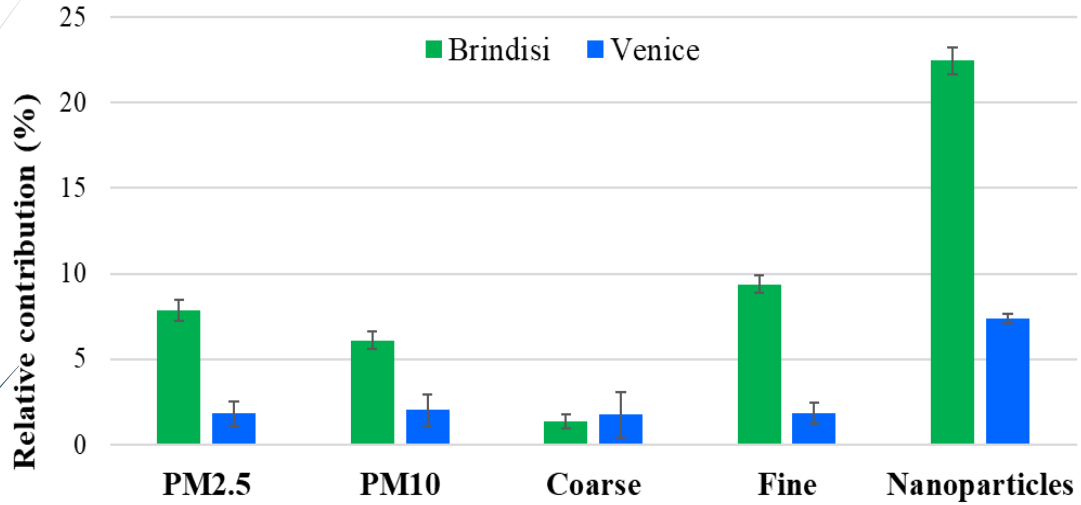
Data post-processing on 30-min averages







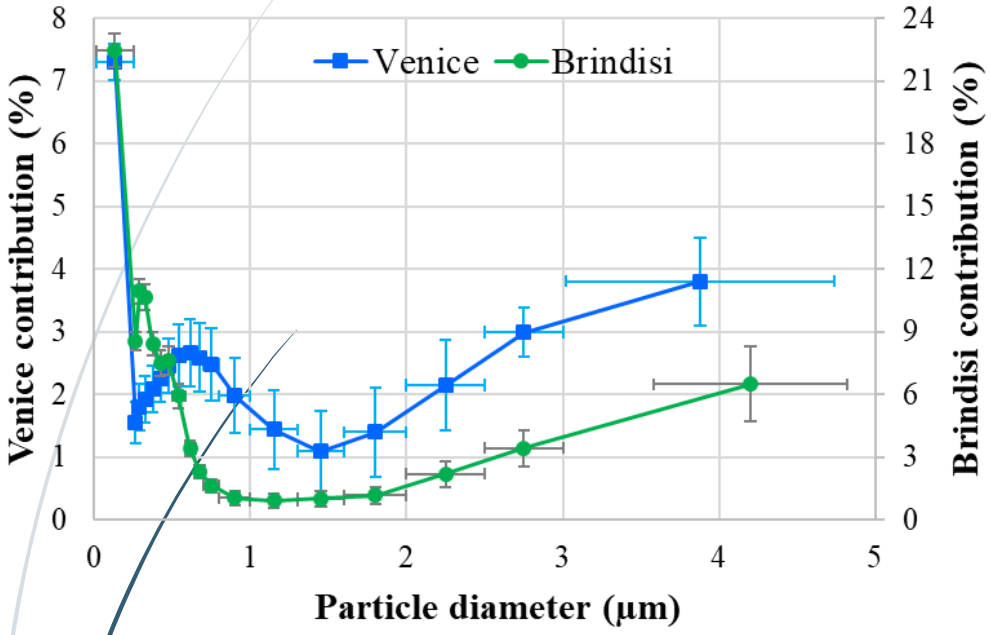
Results – Relative contribution in mass and number



Relative contribution (%):

maximum (both in number and mass) in Brindisi for all size ranges (only comparable for coarse particles)
to number concentration: nanoparticles>fine>coarse particles
to mass concentration: $PM_{2.5}$>PM_{10}

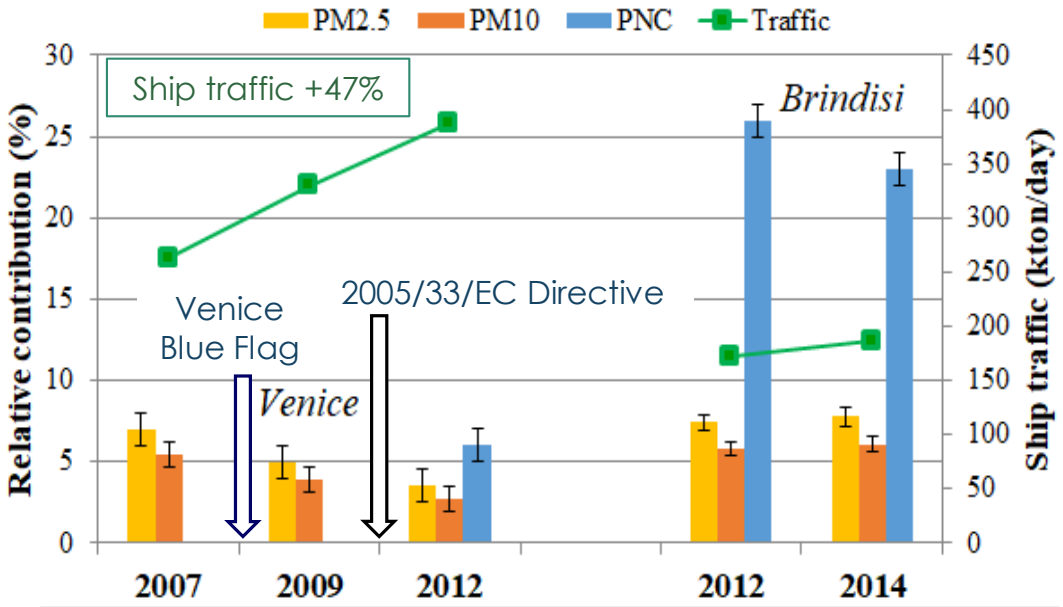
Results – Size-resolved contribution



Size distribution of relative contribution with similarities and some different details in general shape between sites

Absolute **maxima** in nanoparticles range (D_p < 0.25 µm)
Minimums between 1 µm and 1.5 µm
Secondary maximum at 0.3-0.4 µm in Brindisi and between 0.4 and 0.7 µm in Venice
Gradual **increase** in the coarse range

Results – Temporal trends



Comparison between summer campaigns with similar instrumental setup and statistical approach

Venice: decreasing trend both for PM_{10} and $PM_{2.5}$ due to the effectiveness of mitigation strategies

Brindisi: slight decrease (-3%) in relative contribution to PNC in Brindisi (2012-2014) No significant changes in impact to PM (+8% in ship traffic)

Conclusions

Shipping relative contribution decreases from nanoparticles (D_p <0.25 μm) to fine particles with intermediate values for coarse fraction at both sites (Venice and Brindisi)

Impact to number concentration of smaller particles (ultrafine and nanoparticles) could be 3-4 times higher than those to mass concentrations ($PM_{2.5}$ and PM_{10})

Number concentration in nanoparticles range (not included in legislation) could be a suitable metric with respect to air quality standard (PM_{10}, $PM_{2.5}$) to evaluate the «weight» of this source

Further studies on size distribution of particles emitted by ships (eventually with chemical information) are needed

In addition to global reduction strategies, local efforts i.e., regulating emissions from specific type of vessels in manoeuvring and berthing phases, should be implemented, in order to mitigate health effects on coastal population and allow a port sustainable development

Thanks for your attention!

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