

# **La stima delle emissioni navali in ambito portuale**

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# Metodi di stima EMEP 1/3

Category	Title
NFR	1.A.3.d.i(i), 1.A.3.d.i(ii), 1.A.3.d.ii, 1.A.4.c.iii, 1.A.5.b International maritime navigation, international inland navigation, national navigation (shipping), national fishing, military (shipping), and recreational boats
SNAP	080402 National sea traffic within EMEP area 080403 National fishing 080404 International sea traffic (international bunkers) 080304 Inland goods carrying vessels
ISIC	
Version	Guidebook 2019

## TIPO DI PROPULSORE



Turbine a gas

Turbine a vapore

Motori diesel

- low speed
- medium speed
- high speed



Motori benzina

- 2 tempi
- 4 tempi

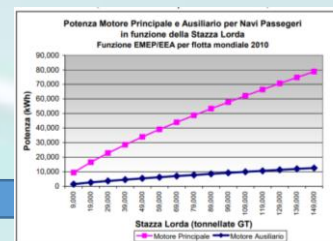
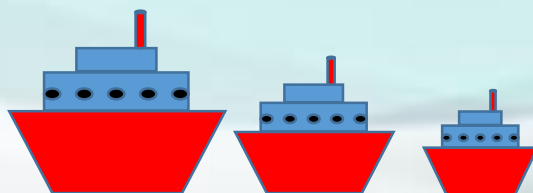
## TIPO DI COMBUSTIBILE



## CATEGORIA NAVE

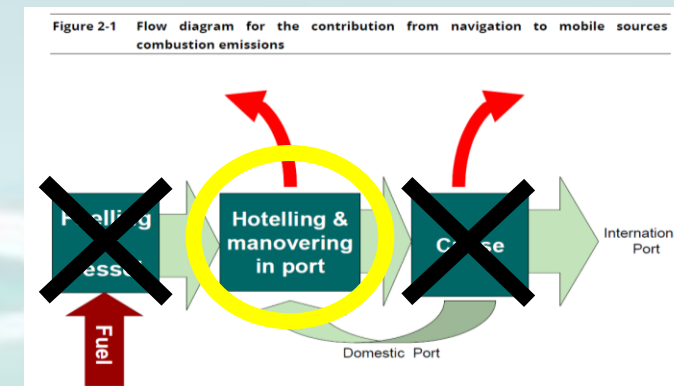
- Liquid bulk ships
- Dry bulk carriers
- Container
- General cargo
- Ro-Ro cargo
- Passenger
- Fishing
- Tugs
- Others

## TONNELLAGGIO



**POTENZA MOTORI** kW

## FASE DI VIAGGIO



# Metodi di stima EMEP 2/3

NUMERO DI INFORMAZIONI NECESSARIE

ACCURATEZZA DELLA STIMA

**Tier 1**

**Tier 2**

**Tier 3**

*Stima  
emissioni in  
navigazione*

- Tipo combustibile
- Consumo combustibile

- Tipo propulsore

- Categorie motore
- Fasi di navigazione

# Metodi di stima EMEP 3/3

E emissione  
FC consumo combustibile  
EF fattore di emissione

**Tier 1**

$$E_i = \sum_m (FC_m \times EF_{i,m})$$

where:

- $E_i$  = emission of pollutant  $i$  in kilograms;
- $FC_m$  = mass of fuel type  $m$  sold in the country for navigation (tonnes);
- $EF_{i,m}$  = fuel consumption-specific emission factor of pollutant  $i$  and fuel type  $m$  [kg/tonne];
- $m$  = fuel type (bunker fuel oil, marine diesel oil, marine gas oil, gasoline).

$i$  inquinante  
 $m$  tipo combustibile  
 $j$  tipo propulsore  
 $p$  fase  
 $e$  categoria propulsore



**Tier 2**

$$E_i = \sum_m \left( \sum_j FC_{m,j} \times EF_{i,m,j} \right)$$

where:

- $E_i$  = emission of pollutant  $i$  in kilograms;
- $FC_{m,j}$  = mass of fuel type  $m$  sold in the country for navigation (tonnes);
- $EF_{i,m,j}$  = fuel consumption-specific emission factor of pollutant  $i$  and fuel type  $m$  and propulsore  $j$  [kg/tonne];
- $m$  = fuel type (bunker fuel oil, marine diesel oil, marine gas oil, gasoline);
- $j$  = propulsore (gas turbine, high-speed diesel, medium-speed diesel, slow-speed diesel, steam turbine).

**Table 3-10 Tier 3 emission factors for NO<sub>x</sub>, NMVOC, PM and Specific Fuel Consumption for different engine types/fuel combinations and vessel trip phases (cruising, manoeuvring, hotelling) in g/kWh**

Engine	Phase	Engine type	Fuel type	NO <sub>x</sub> EF 2000 (g/kWh)	NO <sub>x</sub> EF 2005 (g/kWh)	NO <sub>x</sub> EF 2010 (g/kWh)	NMVOC EF (g/kWh)	TSP PM10 PM2.5 EF (g/kWh)	Specific fuel consumption (g fuel/kWh)
Main	Cruise	Gas turbine	BFO	6.1	5.9	5.7	0.1	0.1	305.0
			MDO/MGO	5.7	5.5	5.3	0.1	0.0	290.0
		High-speed diesel	BFO	12.7	12.3	11.8	0.2	0.8	213.0
			MDO/MGO	12.0	11.6	11.2	0.2	0.3	203.0
		Medium-speed diesel	BFO	14.0	13.5	13.0	0.5	0.8	213.0
			MDO/MGO	13.2	12.8	12.3	0.5	0.3	203.0
		Slow-speed diesel	BFO	18.1	17.5	16.9	0.6	1.7	195.0
			MDO/MGO	17.0	16.4	15.8	0.6	0.3	185.0
		Steam turbine	BFO	2.1	2.0	2.0	0.1	0.8	305.0
	MDO/MGO		2.0	1.9	1.9	0.1	0.3	290.0	
	Manoeuvring Hotelling	Gas turbine	BFO	3.1	3.0	2.9	0.5	1.5	336.0
			MDO/MGO	2.9	2.8	2.7	0.5	0.5	319.0
		High-speed diesel	BFO	10.2	9.9	9.5	0.6	2.4	234.0
			MDO/MGO	9.6	9.3	8.9	0.6	0.9	223.0
		Medium-speed diesel	BFO	11.2	10.8	10.4	1.5	2.4	234.0
			MDO/MGO	10.6	10.2	9.9	1.5	0.9	223.0
		Slow-speed diesel	BFO	14.5	14.0	13.5	1.8	2.4	215.0
			MDO/MGO	13.6	13.1	12.7	1.8	0.9	204.0
Steam turbine		BFO	1.7	1.6	1.6	0.3	2.4	336.0	
	MDO/MGO	1.6	1.6	1.5	0.3	0.9	319.0		
Auxiliary	Cruise Manoeuvring Hotelling	High-speed diesel	BFO	11.6	11.2	10.8	0.4	0.8	227.0
			MDO/MGO	10.9	10.5	10.2	0.4	0.3	217.0
		Medium-speed diesel	BFO	14.7	14.2	13.7	0.4	0.8	227.0
MDO/MGO	13.9	13.5	13.0	0.4	0.3	217.0			

**Table 3-12 Installed main engine power as a function of gross tonnage (GT)**

Ship categories	2010 world fleet	1997 world fleet	Mediterranean Sea fleet (2006)
Liquid bulk ships	14.755*GT <sup>0.6082</sup>	29.821*GT <sup>0.5552</sup>	14.602*GT <sup>0.6278</sup>
Dry bulk carriers	35.912*GT <sup>0.5276</sup>	89.571*GT <sup>0.4446</sup>	47.115*GT <sup>0.504</sup>
Container	2.9165*GT <sup>0.8719</sup>	1.3284*GT <sup>0.9303</sup>	1.0839*GT <sup>0.9617</sup>
General Cargo	5.56482*GT <sup>0.7425</sup>	10.539*GT <sup>0.6760</sup>	1.2763*GT <sup>0.9154</sup>
Ro Ro Cargo	164.578*GT <sup>0.4350</sup>	35.93*GT <sup>0.5885</sup>	45.7*GT <sup>0.5237</sup>
Passenger	9.55078*GT <sup>0.7570</sup>	1.39129*GT <sup>0.9222</sup>	42.966*GT <sup>0.6035</sup>
Fishing	9.75891*GT <sup>0.7527</sup>	10.259*GT <sup>0.6919</sup>	24.222*GT <sup>0.5916</sup>
Other	59.049*GT <sup>0.5485</sup>	44.324*GT <sup>0.5300</sup>	183.18*GT <sup>0.4028</sup>
Tugs	54.2171*GT <sup>0.6420</sup>	27.303*GT <sup>0.7014</sup>	

Source: Trozzi (2010) for 2010 and 1997 world fleets; Entec (2007) for 2006 Mediterranean Sea fleet; (for 1997 fleet a conversion 1 GT = 1.875 GRT was used)

**Tier 3**

$E_{Trip,i,j,m} = \sum_p \left( T_P \sum_e \left( P_e \times LF_e \times EF_{e,i,j,m,p} \right) \right)$

where:

- $E_{Trip,i,j,m}$  = emission of pollutant  $i$  in kilograms;
- $T_P$  = time of vessel;
- $P_e$  = power of vessel;
- $LF_e$  = load factor of vessel;
- $EF_{e,i,j,m,p}$  = emission factor of pollutant  $i$  and fuel type  $m$  and propulsore  $j$  and phase  $p$  and engine category  $e$  [kg/tonne];
- $p$  = phase (cruising, manoeuvring, hotelling);
- $e$  = engine category (gas turbine, diesel engine, steam turbine).

**Table 3-13: Estimated average vessel ratio of Auxiliary Engines / Main Engines by ship type**

Ship categories	2010 world fleet	Mediterranean Sea fleet (2006)
Liquid bulk ships	0.30	0.35
Dry bulk carriers	0.30	
Container	0.25	
General Cargo	0.23	
Ro Ro Cargo	0.24	
Passenger	0.16	
Fishing	0.39	
Other	0.35	
Tugs	0.10	

Source: Trozzi (2010) for 2010 world fleet; Entec (2007) for 2006 Mediterranean Sea fleet

**Table 3-15 Estimated % load of MCR (Maximum Continuous Rating) of Main and Auxiliary Engine for different ship activity**

Phase	% load of MCR		% load of MCR Auxiliary Engine
	Main Engine	% time all Main Engine operating	
Cruise	80	100	30
Manoeuvring	20	100	50
Hotelling (except tankers)	20	5	40
Hotelling (tankers)	20	100	60

Source: Entec (2002)

$T$  tempo  
 $P$  potenza propulsore  
 $LF$  fattore di carico

# Inventario delle emissioni in atmosfera del Lazio

L'Autorità di Sistema Portuale del Mar Tirreno Centro Settentrionale

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Nave	Data Arrivo	Ora Arrivo	Data Partenza	Ora Partenza	Banchina	Tipo Nave	IMO	Call Sign	Stazza Netta	Stazza Lorda	Lunghezza	Larghezza	Altezza	Portata	Pescaggio MAX	Linea
2	NURAGHES	2019-01-01	06:30	2019-01-01	22:35	20	PASSENGER/RO-RO SHIP	9293404	IBLS	18 583	39 798	213.96	26.4	0	3 900	7.3	CIVITAVECCHIA - OLBIA
3	MOBY DADA	2019-01-01	09:40	2019-01-01	20:05	18	PASSENGER/RO-RO SHIP	7911533	IBRI	17 471	34 093	163.99	29	100	1 000	6.88	CIVITAVECCHIA - CAGLIARI
4	KINNE	2019-01-01	18:06	2019-01-03	13:49	23 N	GENERAL CARGO SHIP	9306689	PHAR	1 652	2 810	89	13.35	0	4 775	5.85	CIVITAVECCHIA -
5	ATHARA	2019-01-02	06:45	2019-01-02	22:40	20	PASSENGER/RO-RO SHIP	9263655	IBDI	16 744	35 736	213.96	26.4	0	4 700	7.3	CIVITAVECCHIA - OLBIA
6	MSC CRISTIANA	2019-01-02	08:45	2019-01-02	20:00	26	VEHICLES CARRIER	9453298	3FJT7	25 783	59 835	199.08	32.26			11.2	CIVITAVECCHIA -
7	MOBY TOMMY	2019-01-02	09:10	2019-01-02	19:00	18	PASSENGER/RO-RO SHIP	9221310	ICCS	9 356	32 302	212.09	25		6 075	6.8	CIVITAVECCHIA - ARBATAX
8	GRANDE ITALIA	2019-01-02	09:10	2019-01-02	18:11	25	VEHICLES CARRIER	9227912	IBTF	13 441	37 726	176	31	0	12 594	8.77	CIVITAVECCHIA -
9	CATANIA	2019-01-02	09:40	2019-01-02	15:15	28	PASSENGER/RO-RO SHIP	9261554	IBKM	7 500	25 995	186.35	25.6	0	7 150	6.62	CIVITAVECCHIA - TUNISI
10	BBC KANSAS	2019-01-02	10:28	2019-01-04	10:13	24	GENERAL CARGO SHIP	9349291	V2BM3	4 260	9 611	138.02	21		12 731	8	CIVITAVECCHIA -

**SCHEDE TECNICHE NAVI**

Item	Value	Item	Value
IMO Number	9293404	IMO Number	9293404
Gross Tonnage	39798	Gross Tonnage	39798
Net Tonnage	25784	Net Tonnage	25784
Length	213.96 m	Length	213.96 m
Breadth	26.4 m	Breadth	26.4 m
Draught	6.9 m	Draught	6.9 m
Year of build	2007	Year of build	2007
Operating frequency of the ship	50 hr	Operating frequency of the ship	50 hr
Main Engines	2	Main Engines	2
Number	2	Number	2
Total Power	95440 kW	Total Power	95440 kW
Factory	MAN	Factory	MAN
Type	M/DIA	Type	M/DIA
Power	47720 kW	Power	47720 kW
Speed	18.00 km/h	Speed	18.00 km/h
Number	2	Number	2
Year of build	2007	Year of build	2007
Waste Water Treatment	WWT	Waste Water Treatment	WWT
Capacity	1000 l/h	Capacity	1000 l/h
Year of build	2007	Year of build	2007



**ARPA Lazio**  
+  
**ARIANET**

**MIX TIER 2/TIER 3**

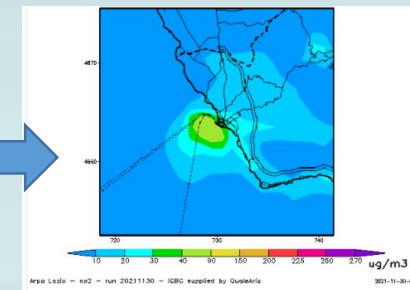


**Emissioni (t/anno) suddivise per tipologia di fase**

	CO	CO2	NMVOG	NOx	SOx	PM10
hotelling	225	97198	66	1550	61	82
manoeuvring	54	23191	31	347	14	44
TOT PORTO	278	120389	97	1897	75	126

**Emissioni complessive (t/anno) suddivise per tipologia di nave**

	CO	CO2	NMVOG	NOx	SOx	TSP
container	26	11451	10	189	7	12
dry bulk carriers	0	139	0	2	0	0
general cargo	10	4345	3	79	3	4
liquid bulk ships	0	203	0	3	0	0
passenger	107	46198	37	714	29	50
ro ro cargo	134	58054	46	919	36	60
Totale	278	120389	97	1897	75	126



**ANNO DI RIFERIMENTO 2018**

**Inventario altre sorgenti**

# Progetto porti ISPRA-ARPA

**Oggetto:** indagine bottom up sulle emissioni da navigazione in ambito portuale

**Obiettivo:** stima delle emissioni da traffico marittimo in ambito portuale su porti rappresentativi italiani tra cui Civitavecchia, Ancona, Livorno, Napoli, Venezia, Trieste, Catania, Messina, Bari, Taranto....

**Quadro di riferimento:** convenzione in ambito SNPA tra ISPRA e alcune ARPA



**ANNO DI  
RIFERIMENTO  
2019**

Applicazione ai porti pilota del Software BUH (Bottom Up Harbour) già sviluppato da ARPA Veneto nell'ambito dei progetti APICE e CAIMAN'S

# Stima emissioni con BUH

**BUH**, per i movimenti delle navi, richiede come **INPUT**:

- orario e data di arrivo;
- tonnellaggio;
- banchina;
- numero di rimorchiatori;
- tipologia di nave (classificazione Guidebook)\*;
- tempo di manovra;
- tempo stazionamento;
- tempo navigazione;

+

Tabelle del  
Guidebook

**EF - Tier 3**

NO<sub>x</sub>  
NMVOC  
PM

**EF - Tier 1**

CO  
SO<sub>2</sub>  
microinq.

**EF – IPCC 2006**

CO<sub>2</sub>

## **OUTPUT:**

- emissioni totali per tipologia di nave;
- consumi di carburante;
- emissioni per singolo movimento;
- emissioni orarie per l'anno intero con distinzione tra fase di stazionamento e fase di manovra per ogni punto di ormeggio.

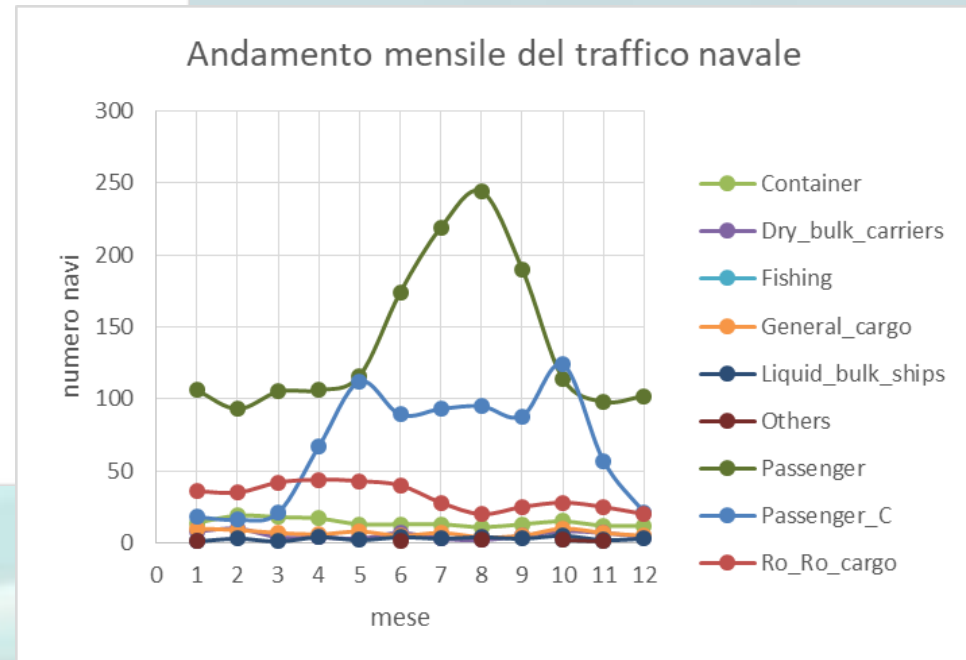
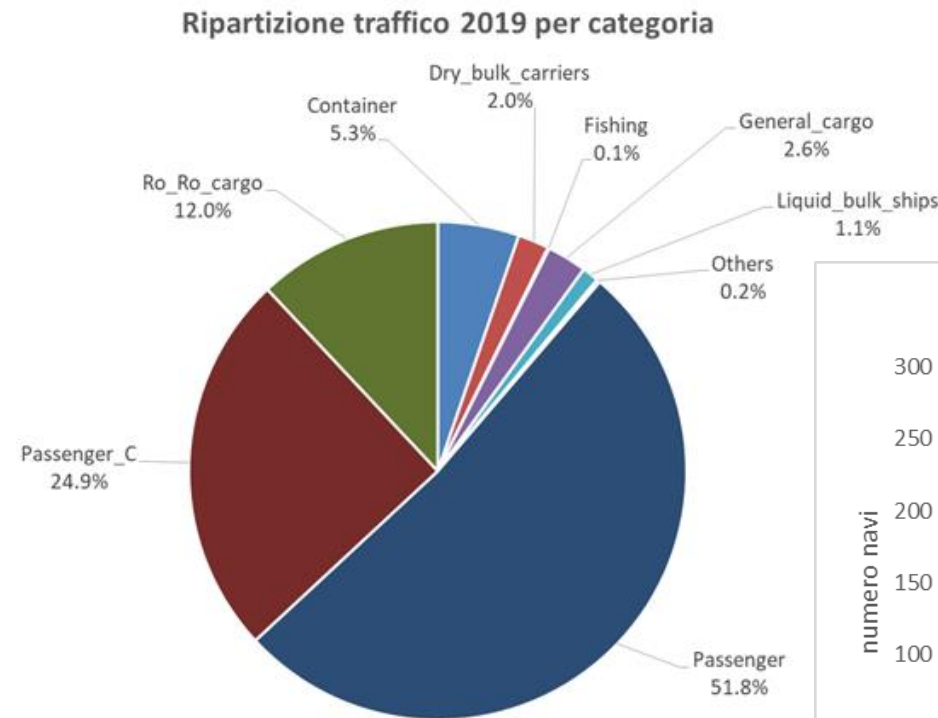
\* le navi Passenger sono state distinte in

- Passenger (traghetti e Ro Pax)
- Passenger\_C (navi da crociera)

# Applicazione al porto di Civitavecchia

## Traffico 2019

Categoria nave	N accosti
Container	170
Dry_bulk_carriers	65
General_cargo	83
Liquid_bulk_ships	35
Passenger	1667
Passenger_C	801
Ro_Ro_cargo	386
Fishing	3
Others	7
<b>TOTALE</b>	<b>3217</b>





# Applicazione al porto di Civitavecchia

## I elaborazione: solo navi

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	ID	year_arr_berth	month_arr_berth	day_arr_berth	hour_arr_berth	min_arr_berth	GT	ID_Terminal	N_tugs	EMEP_ship_category	Total_Manoeuvring_time(hh.dec)	Total_Hotelling_time(hh.dec)	Cruise_lenght(km)	
2	1	2019	1	1	6	30	39798	20	0	Passenger	1	16.1	0	
3	2	2019	1	1	9	40	34093	18	0	Passenger	1	10.4	0	
4	3	2019	1	1	18	6	2810	37	0	General_cargo	1	19.7	0	
5	4	2019	1	2	6	45	35736	20	0	Passenger	1	15.9	0	
6	5	2019	1	2	8	45	59835	26	0	Fo_Ro_cargo	1	11.3	0	
7	6	2019	1	2	9	10	32302	18	0	Passenger	1	9.8	0	

## II elaborazione: solo rimorchiatori

Anno	Numero prestazioni			Consumi Rimorchiatori
	Porto	TVN	Totale	
2019	1.975	312	2.287	580 Mg

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ID	year_arr_berth	month_arr_berth	day_arr_berth	hour_arr_berth	min_arr_berth	GT	ID_Terminal	N_tugs	EMEP_ship_category	Total_Manoeuvring_time(hh.dec)	Total_Hotelling_time(hh.dec)	Cruise_lenght(km)
2	1	2019	1	1	12	0	358	1	0	Tugs	0.75	0	0
3	2	2019	1	1	12	0	358	1	0	Tugs	0.75	0	0
4	3	2019	1	1	12	0	358	1	0	Tugs	0.75	0	0
5	4	2019	1	1	12	0	358	1	0	Tugs	0.75	0	0
6	5	2019	1	1	12	0	358	1	0	Tugs	0.75	0	0

MATCHING consumo combustibile

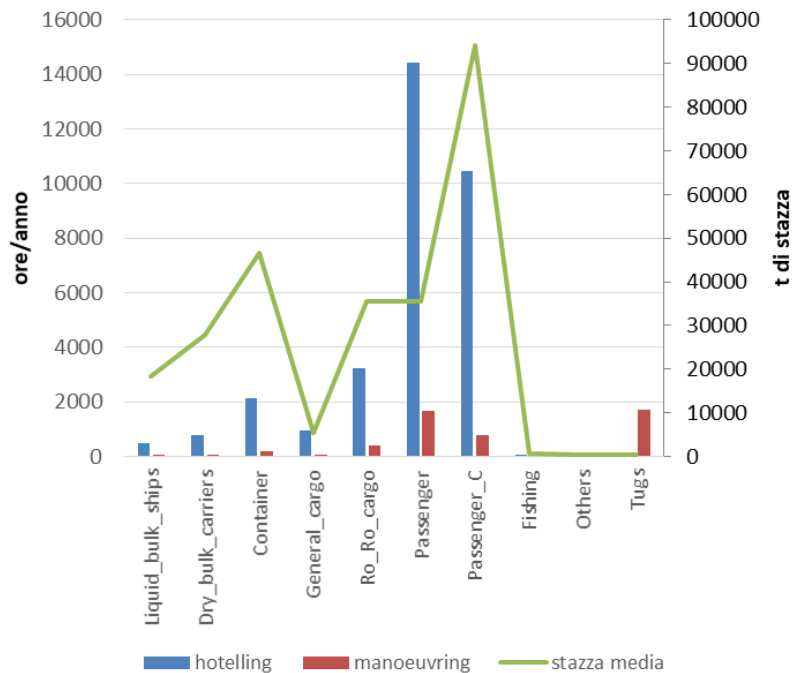
596 Mg

2 dicembre 2021

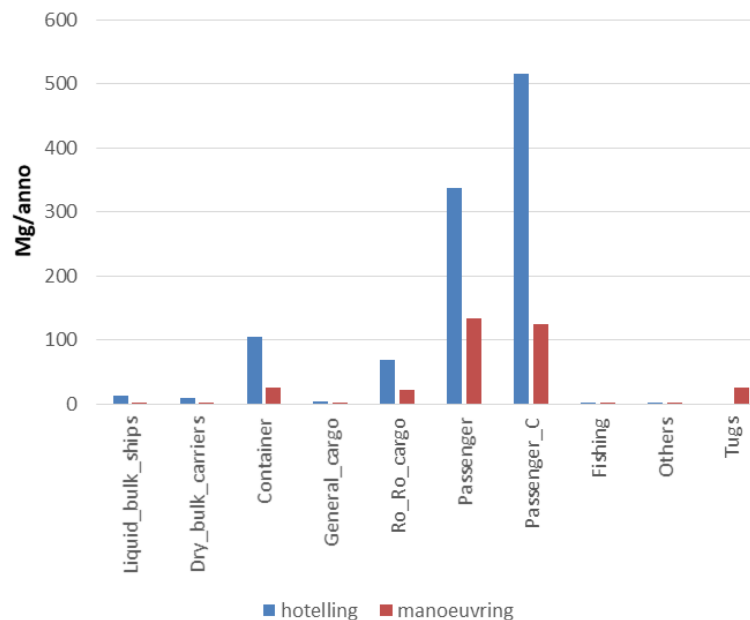
# Applicazione al porto di Civitavecchia

## Risultati 1/2

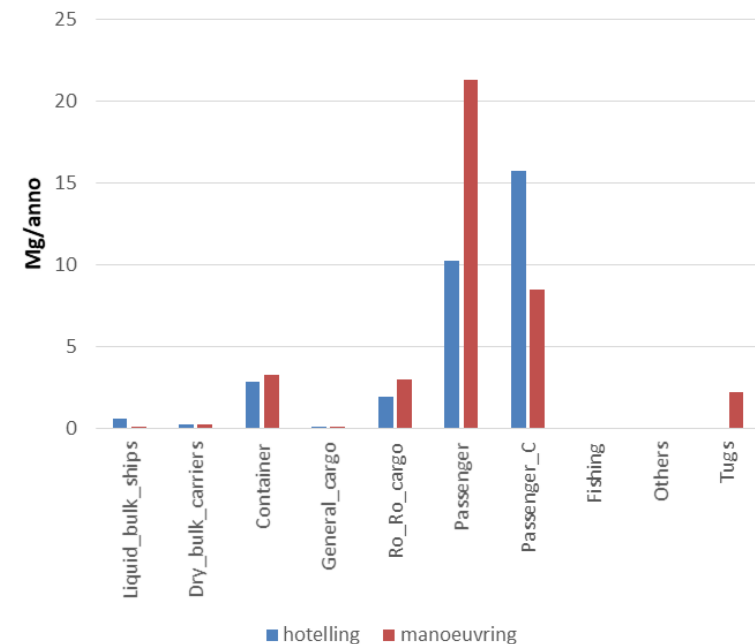
Tempi totali (ore) - CIVITAVECCHIA 2019



Emissioni NOx (t) - CIVITAVECCHIA 2019



Emissioni PM (t) - CIVITAVECCHIA 2019



	NOx (t)	NM VOC (t)	PM (t)	CO (t)	CO2 (kt)
<b>hotelling</b>	<b>1054</b>	<b>45</b>	<b>32</b>	<b>137</b>	<b>59</b>
<b>manoeuvring</b>	<b>335</b>	<b>34</b>	<b>39</b>	<b>53</b>	<b>23</b>
<b>totale</b>	<b>1389</b>	<b>79</b>	<b>71</b>	<b>190</b>	<b>82</b>

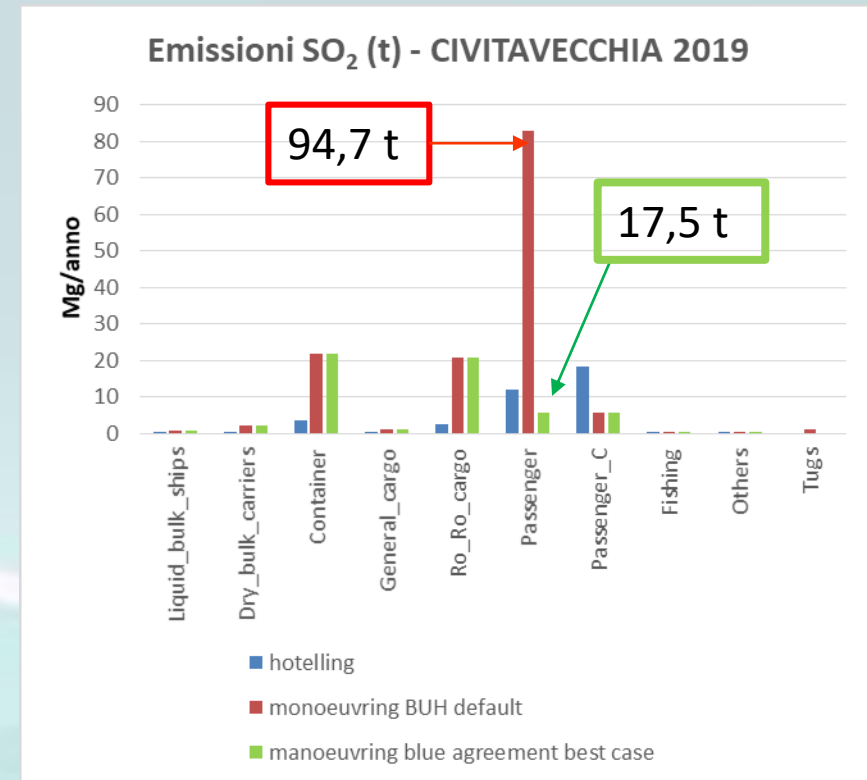
# Applicazione al porto di Civitavecchia

## Risultati 2/2

### Art. 295 Dlgs 152/06 e smi

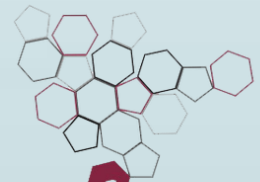
- Vieta utilizzo in acque territoriali, zone economiche esclusive di combustibili marini con tenore di zolfo superiore al 3,50% in massa dal 18 giugno 2014. Dal 1° gennaio 2020 è previsto un limite del 0,50% in massa
- Vieta immissione in mercato di gasoli marini con tenore di zolfo superiore al 0,10% in massa
- Vieta immissione in mercato di oli diesel marini con tenore di zolfo superiore al 1,50% in massa
- Vieta utilizzo in acque territoriali, zone economiche esclusive di combustibili marini con tenore di zolfo superiore al 1,50% in massa per navi passeggeri, le quali effettuano un servizio di linea proveniente da o diretto ad un porto di un Paese dell'Unione Europea
- Vieta utilizzo di combustibili marini con tenore di zolfo superiore a 0,10% in massa per navi all'ormeggio

### Ipotesi default BUH vs Best case



# Approfondimenti e sviluppi futuri

- Aggiornamenti all'inventario con i dati degli accosti del 2020
- Effettuazione confronto tra stima Arianet e stima BUH su uno stesso dataset (stesso anno di riferimento, stessa classificazione navi, stesse ipotesi)
- Con ISPRA - verifica della coerenza tra le rilevazioni ISTAT e i dati puntuali forniti dall'Autorità Portuale



Sistema Nazionale  
per la Protezione  
dell'Ambiente

# Grazie per l'attenzione

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