



Proposal for MEPC New Output on PM Emission from Ships

Team PMaster



Index

1

Particulate Matter

- What's PM
- Damage

2

Perspective of Maritime Industries about PM

- PM from Ship
- IMO

3

Current Cases for Abating PM

4

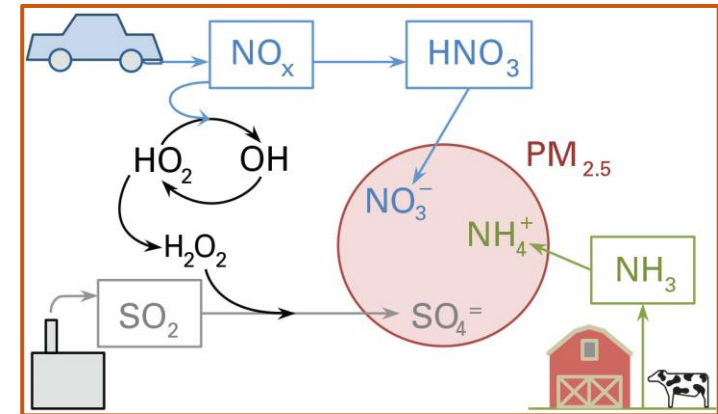
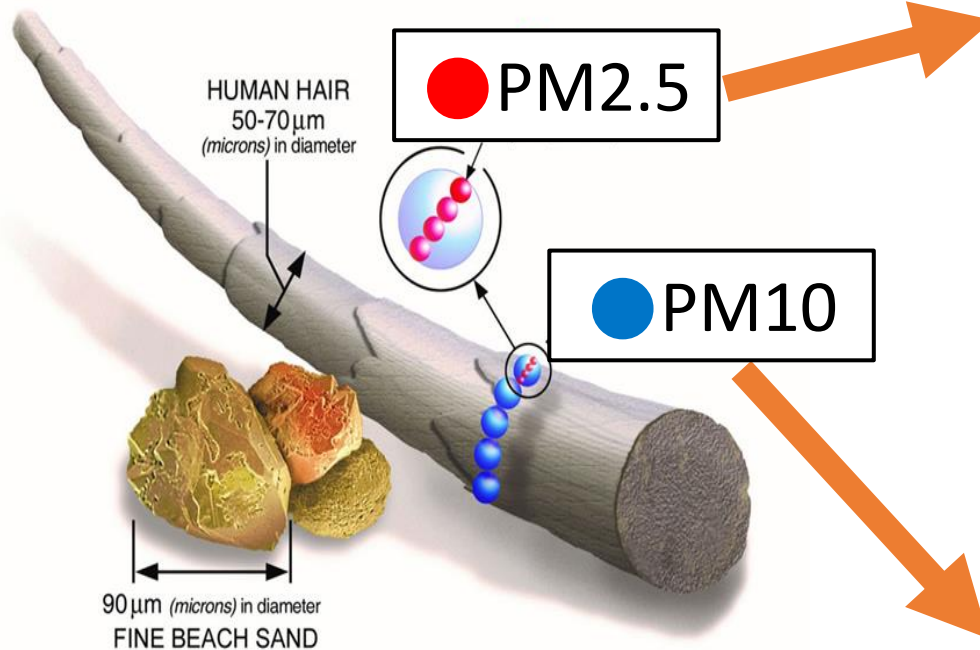
Proposal for New Output

1. Particulate Matter



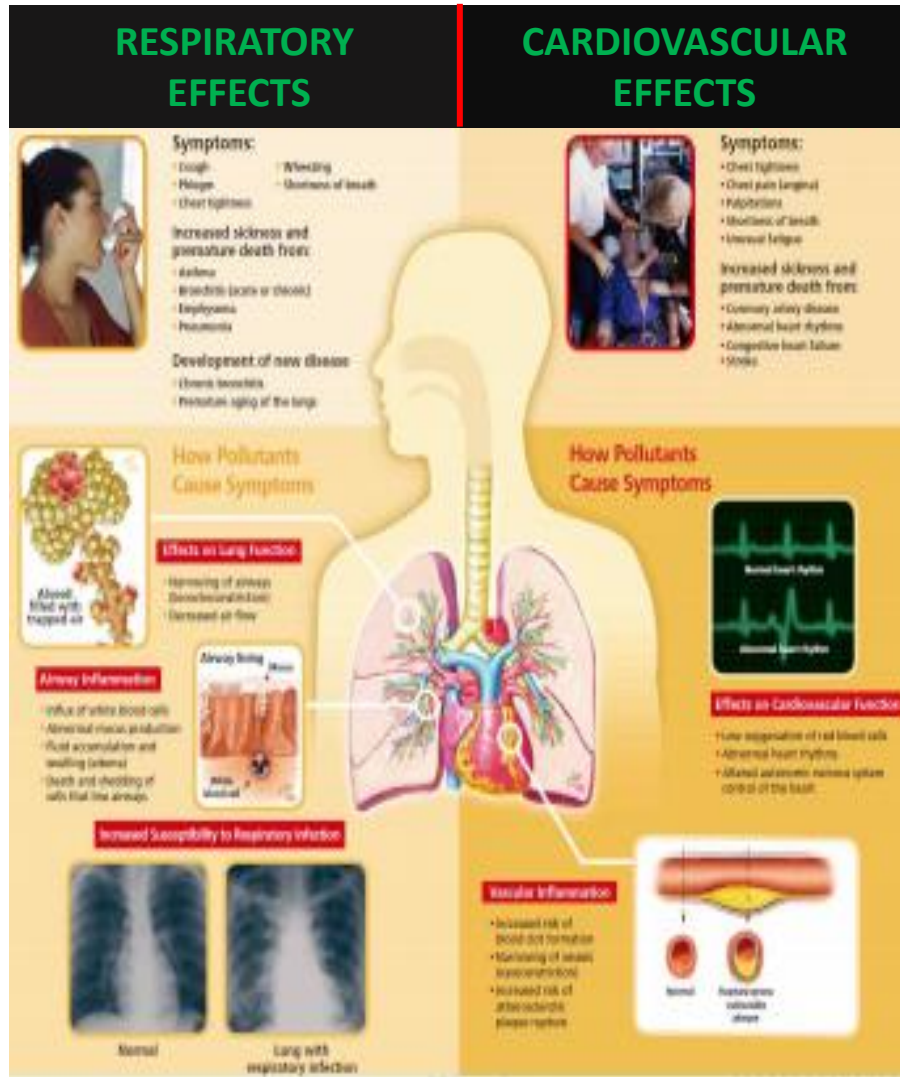
1. Particulate Matter

What's PM

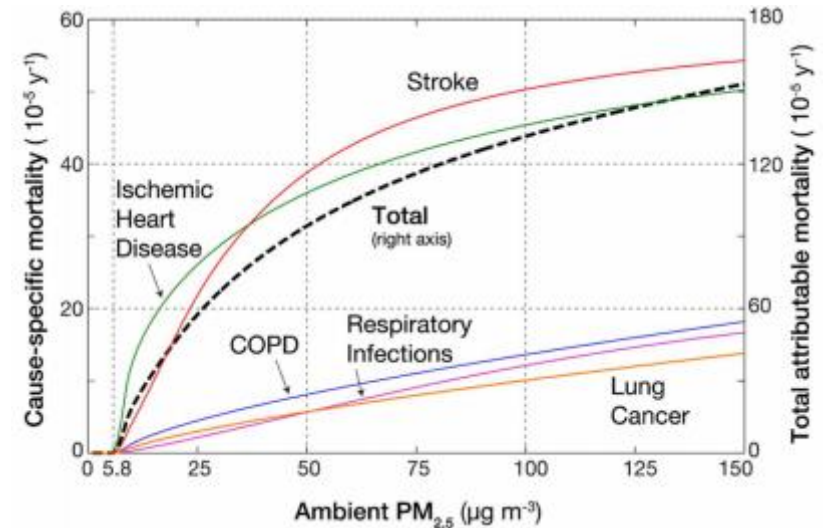


- Dust
- Pollen
- Mold
- **Black Carbon**

Damage



Effects of PM on the human body



The relationship between PM concentration and mortality rate

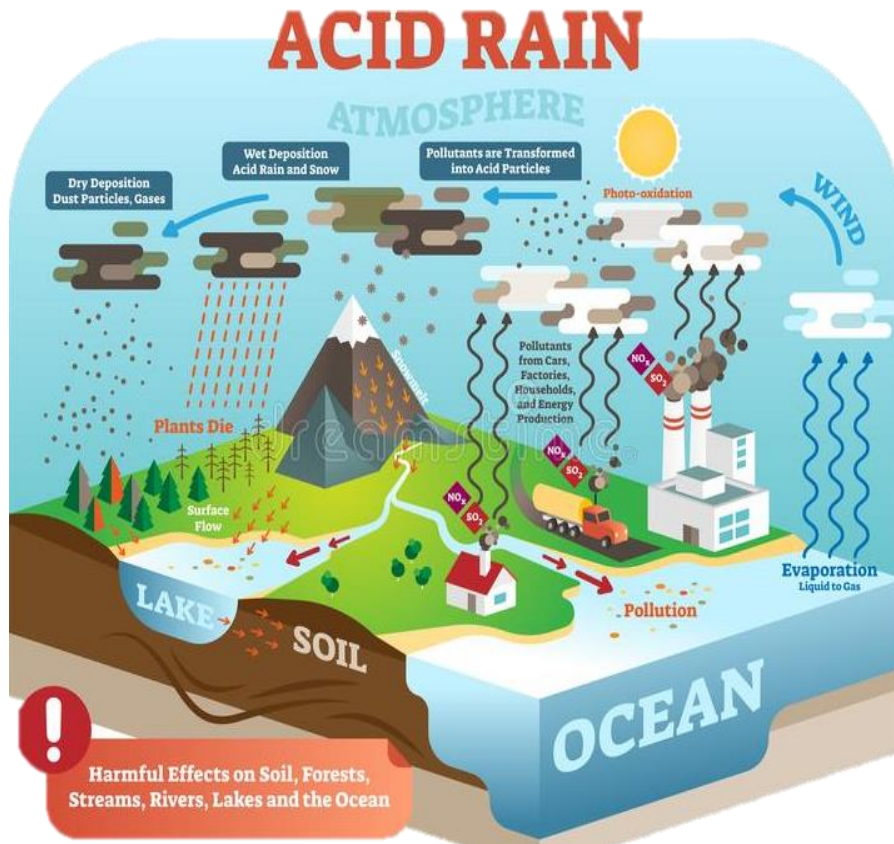
*"The IARC under the **WHO** classified **PM** as a group 1 carcinogen in October 2013"*

*"The **WHO** announced that **7 million** people died earlier in 2014 due to **PM**"*

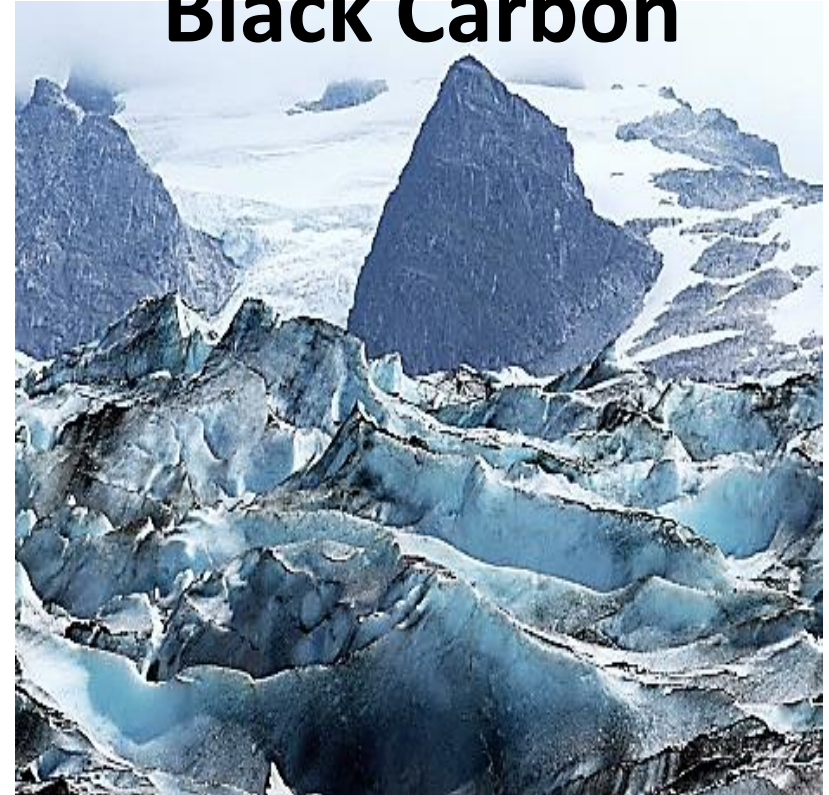
1. Particulate Matter

On Environment

Damage



Black Carbon

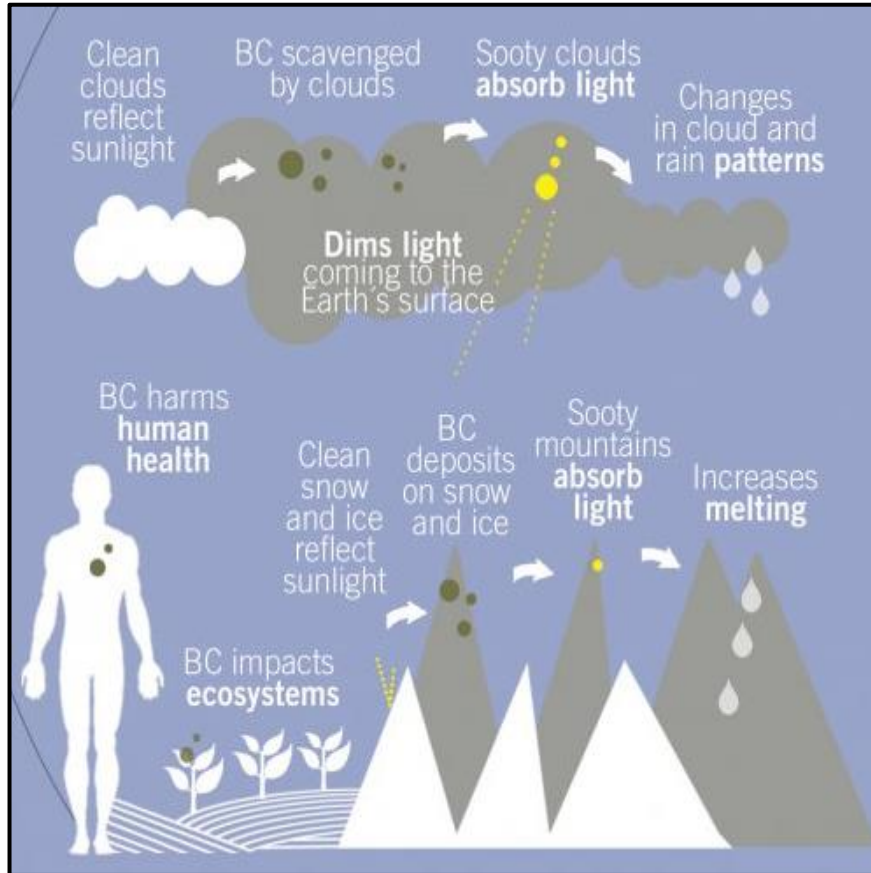


Visual Black Carbon on ice in Arctic

1. Particulate Matter

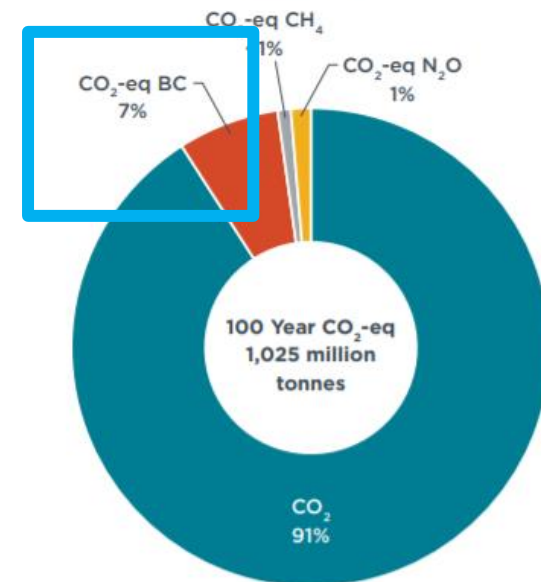
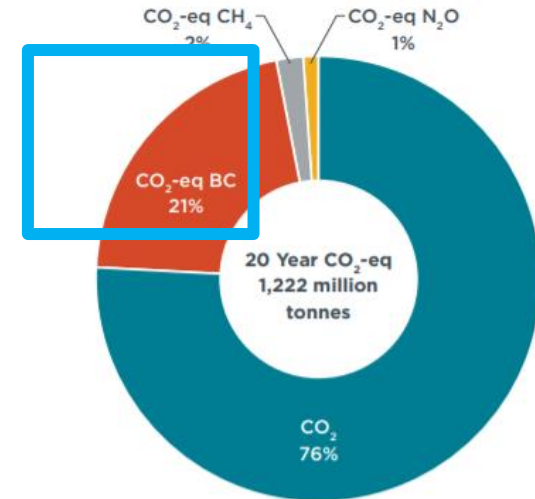
On Environment

Damage



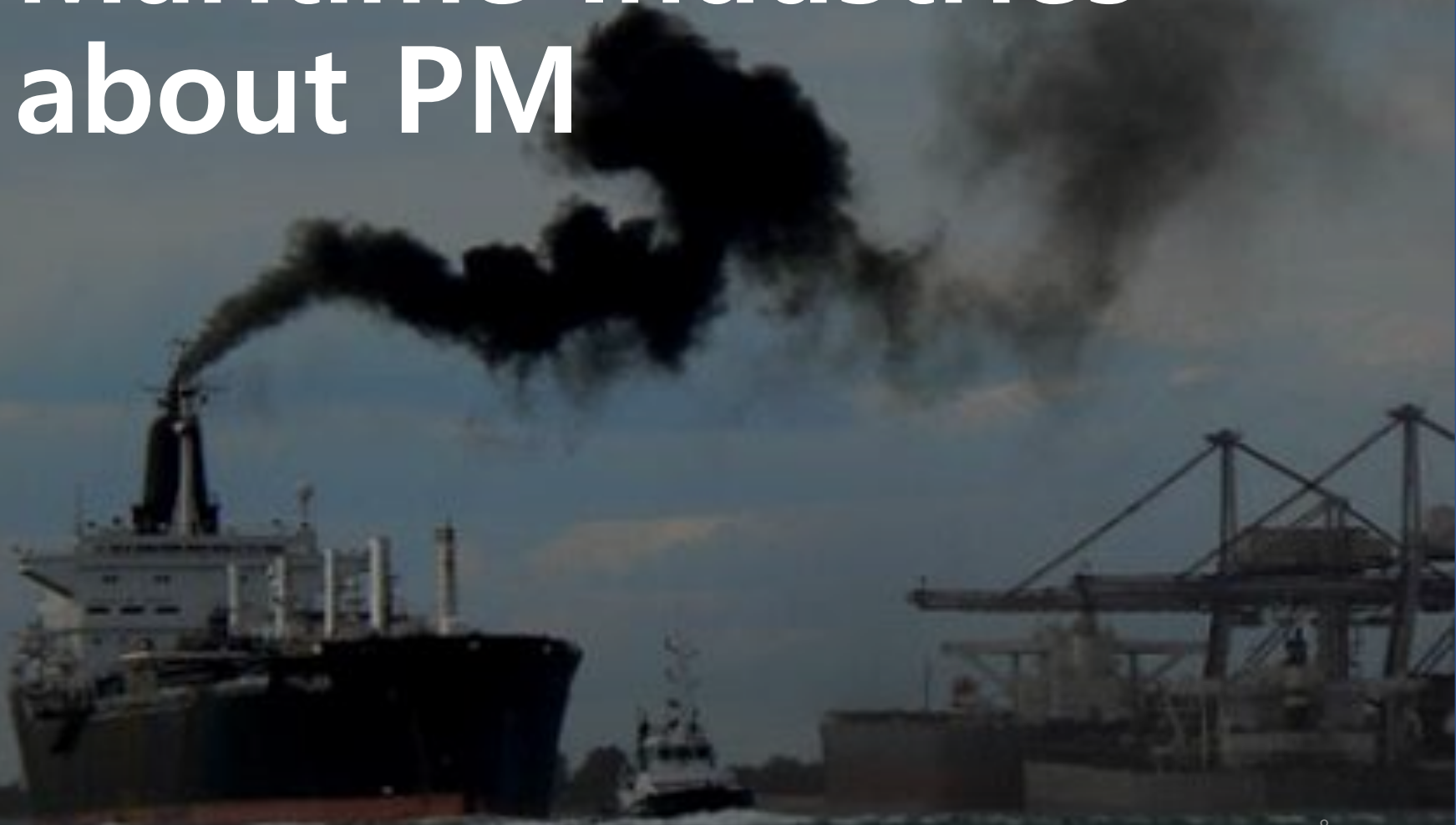
Infographic of Black Carbon

*"BC is a dangerous local air pollutant which can also be **transported across the globe.**"*



Total shipping CO₂-eq emissions, 20-years and 100 year GWP, 2015

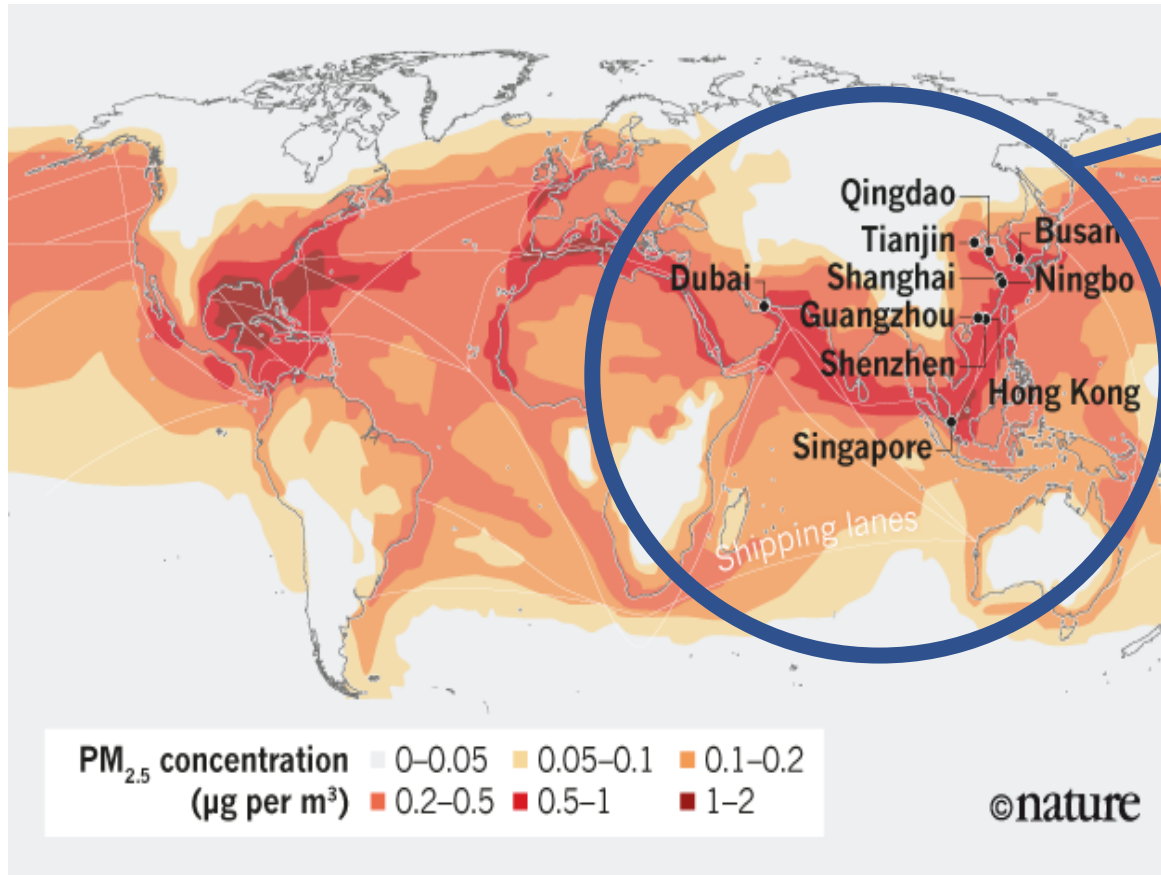
2. Perspective of Maritime Industries about PM



2. Perspective of Maritime Industries about PM

PM from Ship

Dirty 10



Asia Area

"Top 10 ports worldwide with the highest level of PM emissions"

"High PM concentration along the shipping lanes"

2. Perspective of Maritime Industries about PM

PM from Ship

China Port

✓ Bohai Rim Area (BRA)

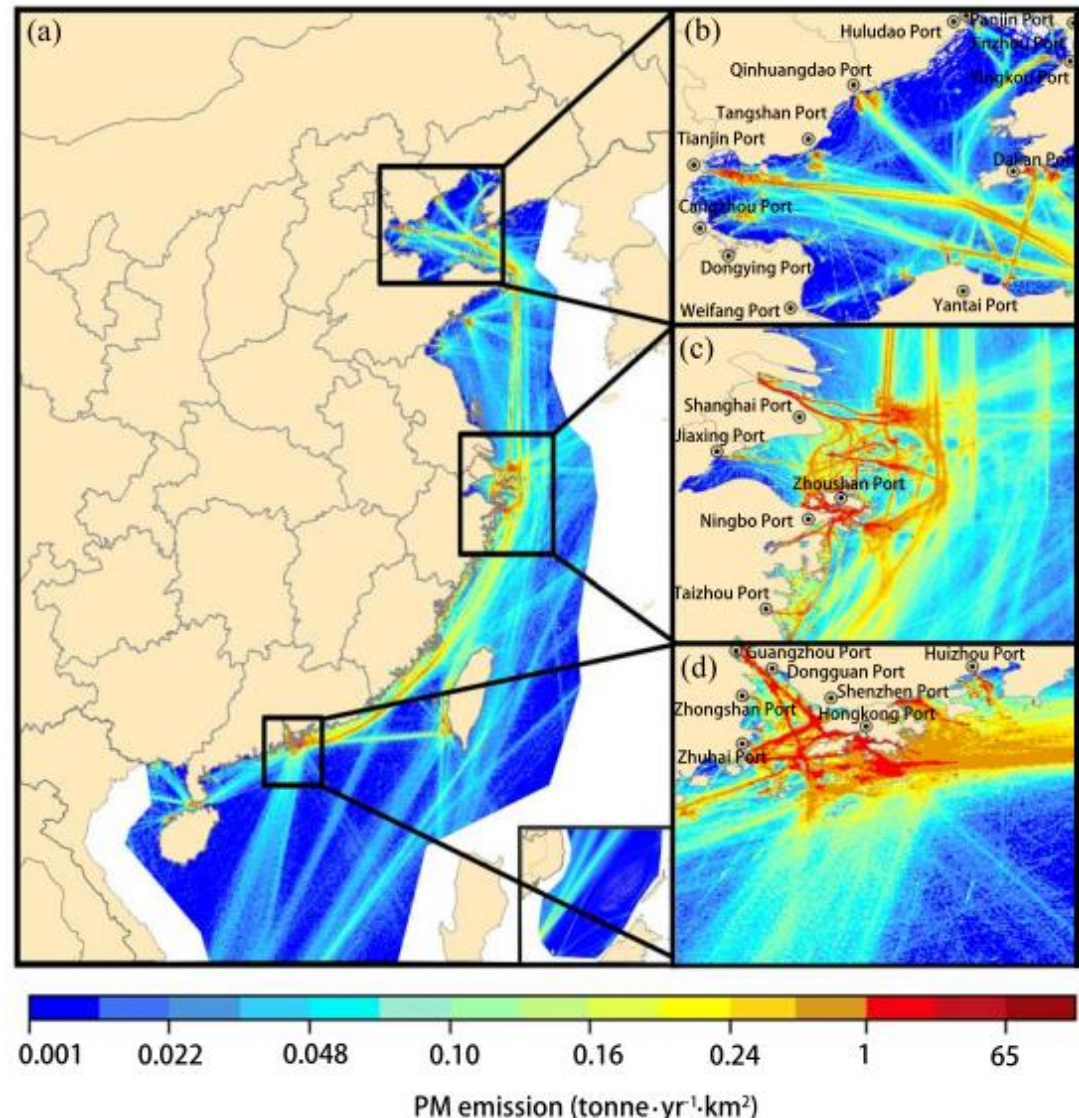
- Tianjin Port
- Qingdao Port

✓ Yangtze River Delta (YRD)

- Shanghai Port
- Ningbo Port

✓ Pearl River Delta (PRD)

- Guangzhou Port
- Shenzhen Port
- Hongkong Port



Spatial distribution of PM emissions from maritime transportation in China

2. Perspective of Maritime Industries about PM

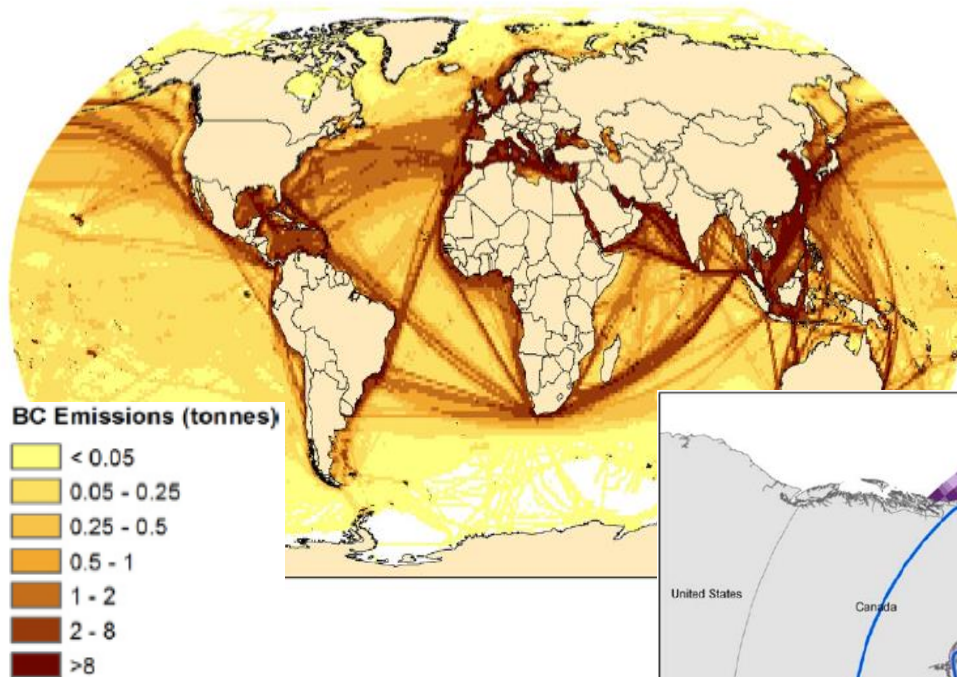
PM from Ship

Busan Port in South Korea

구분		NOx	SOx	PM10	PM2.5	VOCs
total emissions	Busan	43,755	10,659	6,607	2,458	42,207
	Incheon	49,460	12,854	8,292	2,730	54,211
	Ulsan	47,506	47,979	5,910	2,987	98,781
		104,037	64,649	33,854	16,140	85,226
	Nationwide	1,157,728	352,292	233,177	98,806	1,010,771
ship's emissions	Busan	17,997	7,487	1,022	928	854
	Incheon	3,873	1,584	237	217	544
	Ulsan	8,147	3,468	464	421	288
		15,225	6,172	875	797	1,196
	Nationwide	151,735	38,467	7,091	6,539	20,970
The ratio of ship emissions to total emissions(%)	Busan	41.1	70.2	15.5	37.8	2.0
	Incheon	7.8	12.3	2.9	7.9	1.0
	Ulsan	17.2	7.2	7.9	14.1	0.3
		14.6	9.5	2.6	4.9	1.4
	Nationwide	13.1	10.9	3.0	6.6	2.1

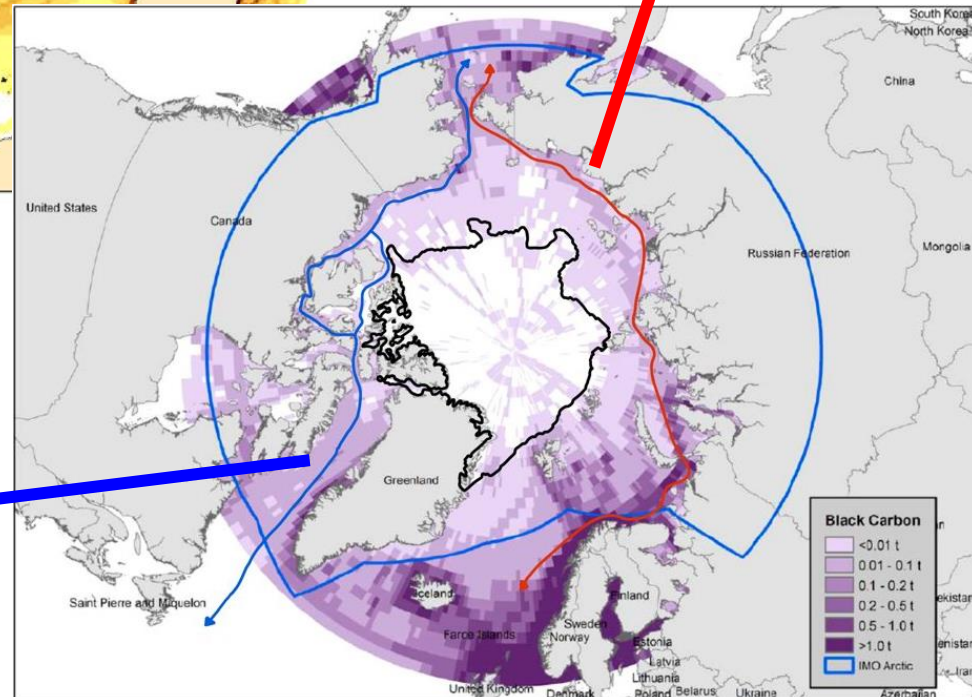
2. Perspective of Maritime Industries about PM

PM from Ship



**Northern
Sea Route**

**Northwest
Passage**



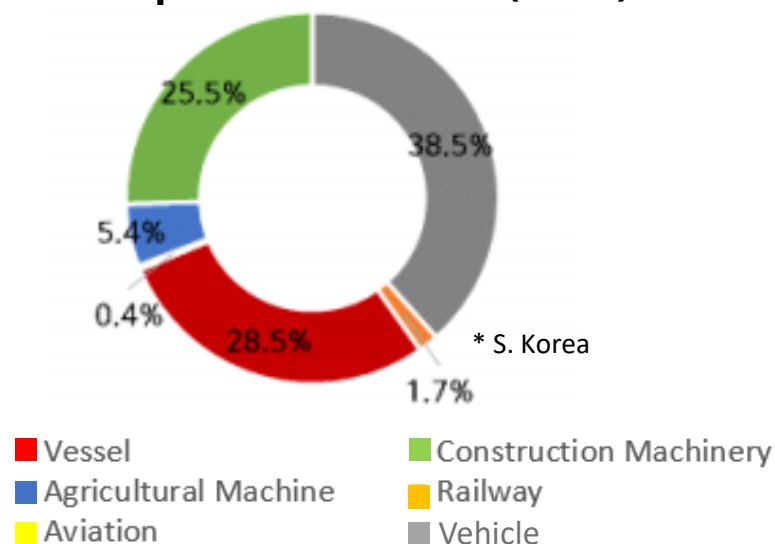
2. Perspective of Maritime Industries about PM

PM from Ship

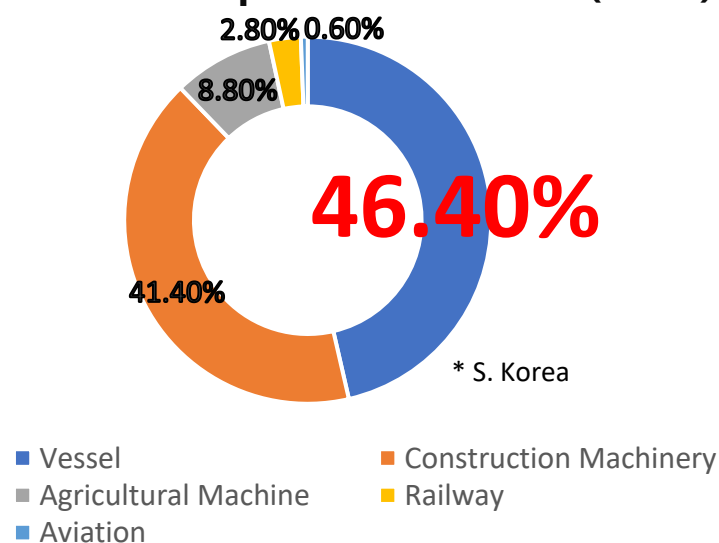
	Total Emissions	Ship's Emissions	The Ratio
NOx	1,135,743	144,030	(12.7%)
SOx	343,161	39,074	(11.4%)
PM10	97,918	6,983	(7.1%)
PM2.5	63,286	6,423	(10.1%)

* S. Korea
(2014)

PM emission amount of
mobile pollution sources(2015)



PM emission amount of
Off road mobile pollution sources(2015)



2. Perspective of Maritime Industries about PM

IMO

	Regulation	Area	Year										Remarks
			2013	214	2015	2016	2017	2018	2019	2020	2021	2022	
Nox	MARPOL Annex 6 Regulation 13	ECA	Tier II (14.4 g/kWh)			Tier III (3.4g/kWh, n<130, 9 n ^(-0.2) g/kWh, n<2000							Similar stage of constructions
		GLOBAL	Tier II (14.4 g/kWh) n<130, n<130, 44 n ^(-0.23) g/kWh, n<2000										
SOx	MARPOL Annex 6 Regulation 14	ECA	1.0 %S		0.1 %S								Review in 2018 if no, will be delayed to 2025
		GLOBAL	3.5 %S						0.5 %S				
PM	US-EPA	ECA/GLOBAL	Under Discussions										US-EPA: Already applied

Under Discussions...



On MARPOL ANNEX VI

Chapter 3 – Requirements for control of emission from ships

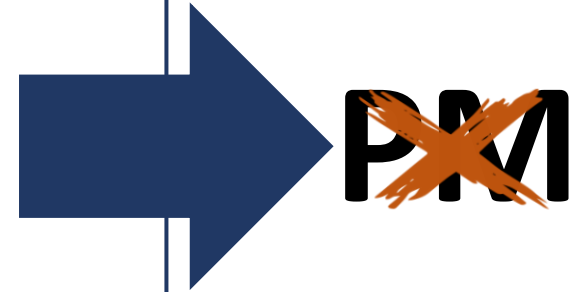
Reg. 12 Ozone Depleting Substances

Reg. 13 Nitrogen Oxides (NO_x)

Reg. 14 Sulphur Oxides (SO_x) and Particulate Matter

Reg. 15 Volatile Organic Compounds (VOCs)

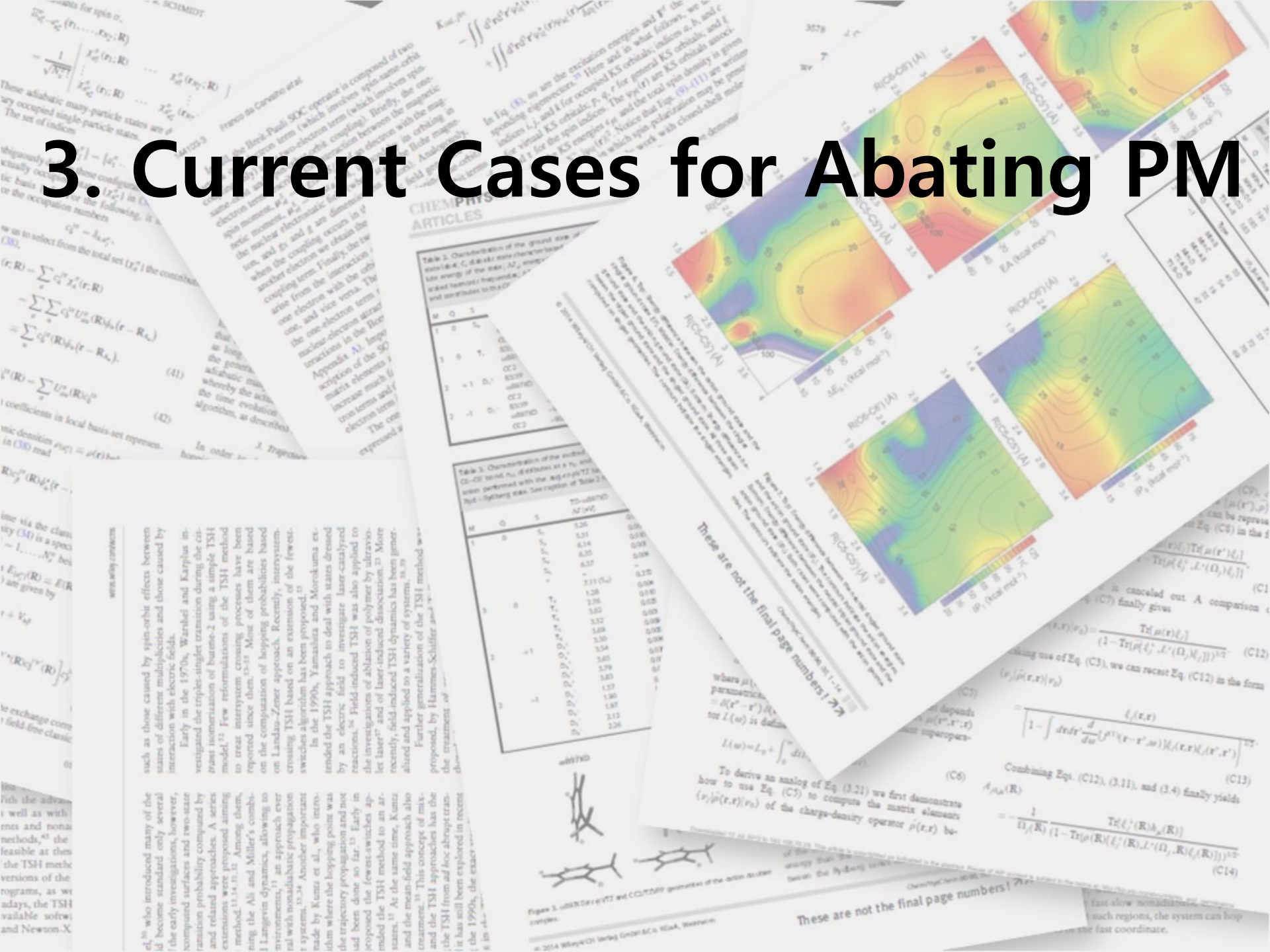
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55 There are no provisions for PM in regulation 14, but it is recognized that the sulphur content of fuel oil relates to the PM of the exhaust. PM consists of particles of soot or smoke resulting from the burning of, primarily, heavier oils. It is considered to be a major health hazard as particulates may penetrate deep into the lungs and blood and cause cancer (see also Black Carbon discussion below).

*Note by the International Maritime Organization to the UNFCCC Talanoa Dialogue

3. Current Cases for Abating PM



3. Current Cases for Abating PM



Goal : Reducing port PM by more than 50% by 2022

*MOF-MOE



China I	China II	China V
20%	40%	92%

Engine type	Per-cylinder displacement (L)	Rated net power (kW)	PM (g/kWh)
Category 1	<0.9	≥37	0.40
	0.9-1.2		0.30
	1.2-5		0.20
Category 2	5-15		0.27
	15-20	<3,300	0.50
		≥3,300	0.50
	20-25		0.50
	25-30		0.50

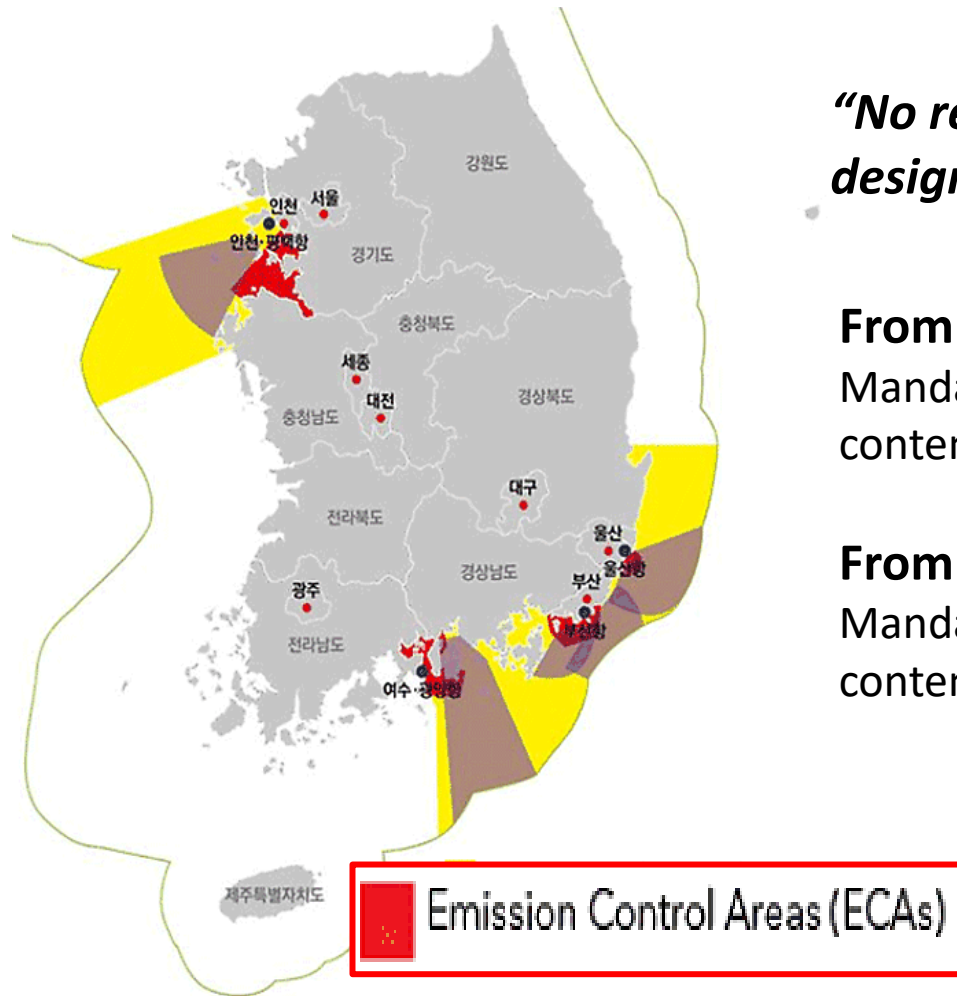
*Only applies to marine engines running on natural gas (including dual fuel).

Engine type	Per-cylinder displacement (L)	Rated net power (kW)	PM (g/kWh)
Category 1	<0.9	≥37	0.30
	0.9-1.2		0.14
	1.2-5		0.12
Category 2	5-15	<2,000	0.14
		2,000-3,700	0.14
		≥3,700	0.27
	15-20	<2,000	0.34
		2,000-3,300	0.50
		≥3,300	0.50
	20-25	<2,000	0.27
		≥2,000	0.50
	25-30	<2,000	0.27
		≥2,000	0.50

*Only applies to marine engines running on natural gas (including dual fuel).

Emission Control Areas (ECA)

Case of South Korea



“No relation to international ECA designated by the IMO”

From 1. 9. 2020 :

Mandatory to use **0.1%** Sulphur contents fuel while at **berthing and anchoring**

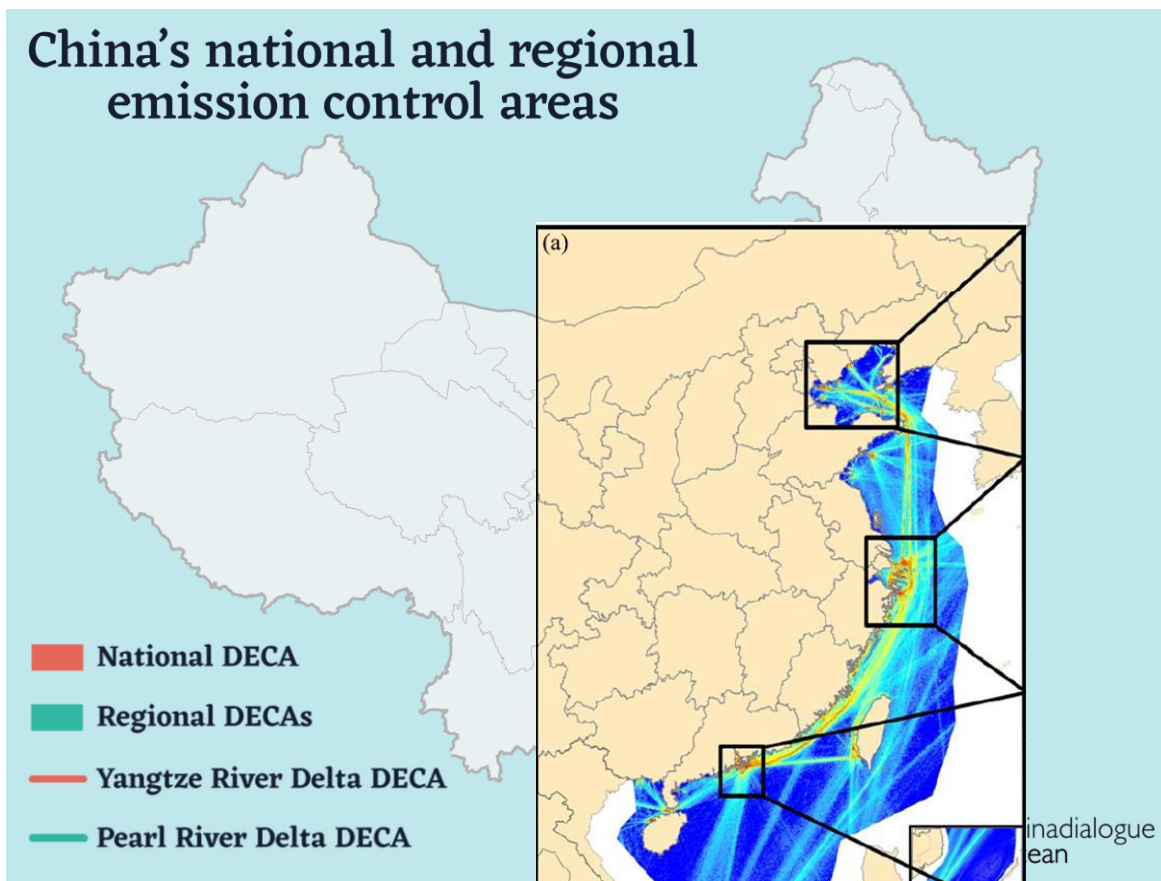
From 1. 1. 2022 :

Mandatory to use **0.1%** Sulphur contents fuel while **navigating ECA**

Domestic Emission Control Areas(DECAs)

Case of China

China's national and regional emission control areas



Regional DECAs

Bohai Rim Area,
Yangtze River Delta,
Pearl River Delta

National DECAs

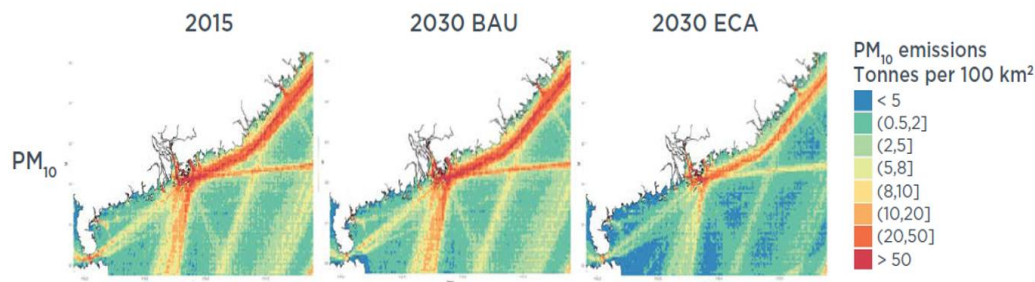
Coastal control areas
Inland control areas

Reduction figures

0.50% for ships entering ECA

Effects of ECA

Pollutant	Emissions (thousand tonnes)			Change in 2030 emissions due to the ECA
	2015	2030 BAU	2030 ECA-control	
SO _x	122	44.4	13.1	-70%
NO _x	195	326	286	-12%
PM ₁₀	16.6	16.1	7.73	-52%



Distribution of ship emissions in the GPRD region in 2015 and 2030, BAU versus with an ECA

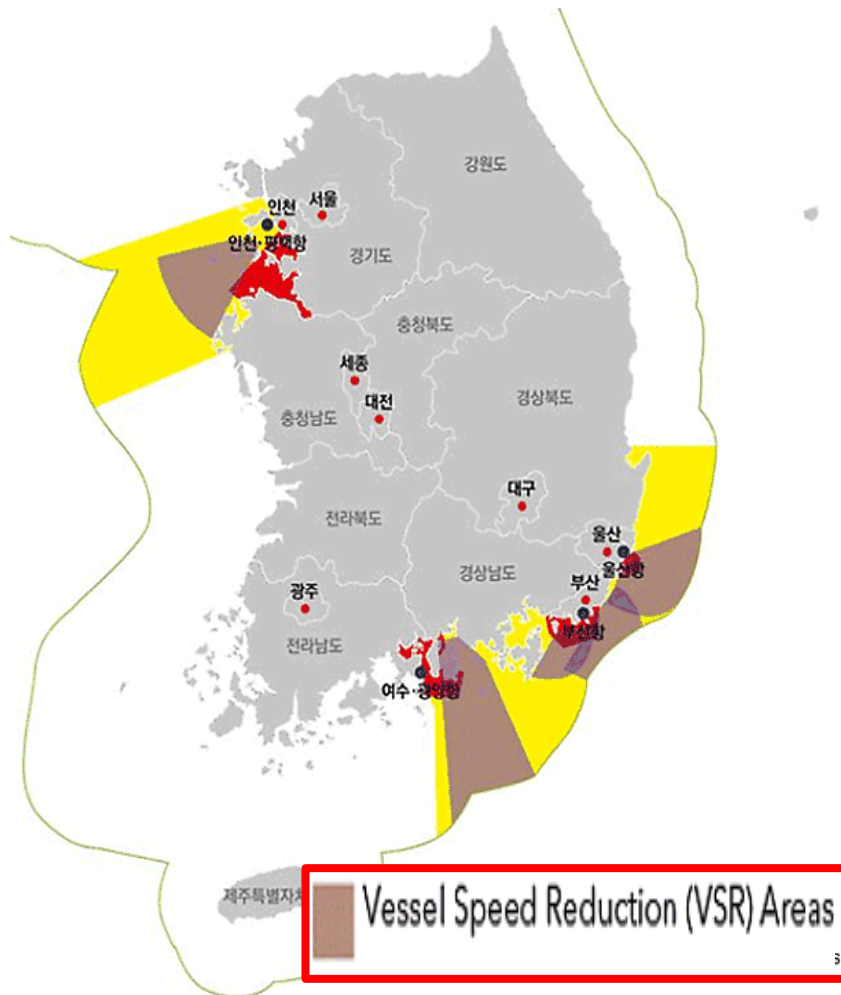
Predicted PM Reduction

USA ECA : -74%

MED ECA : -23.7%

Vessel Speed Reduction(VSR) Program

Case of South Korea



Area

20NMs in radius from specific lighthouse in each port

Advantage

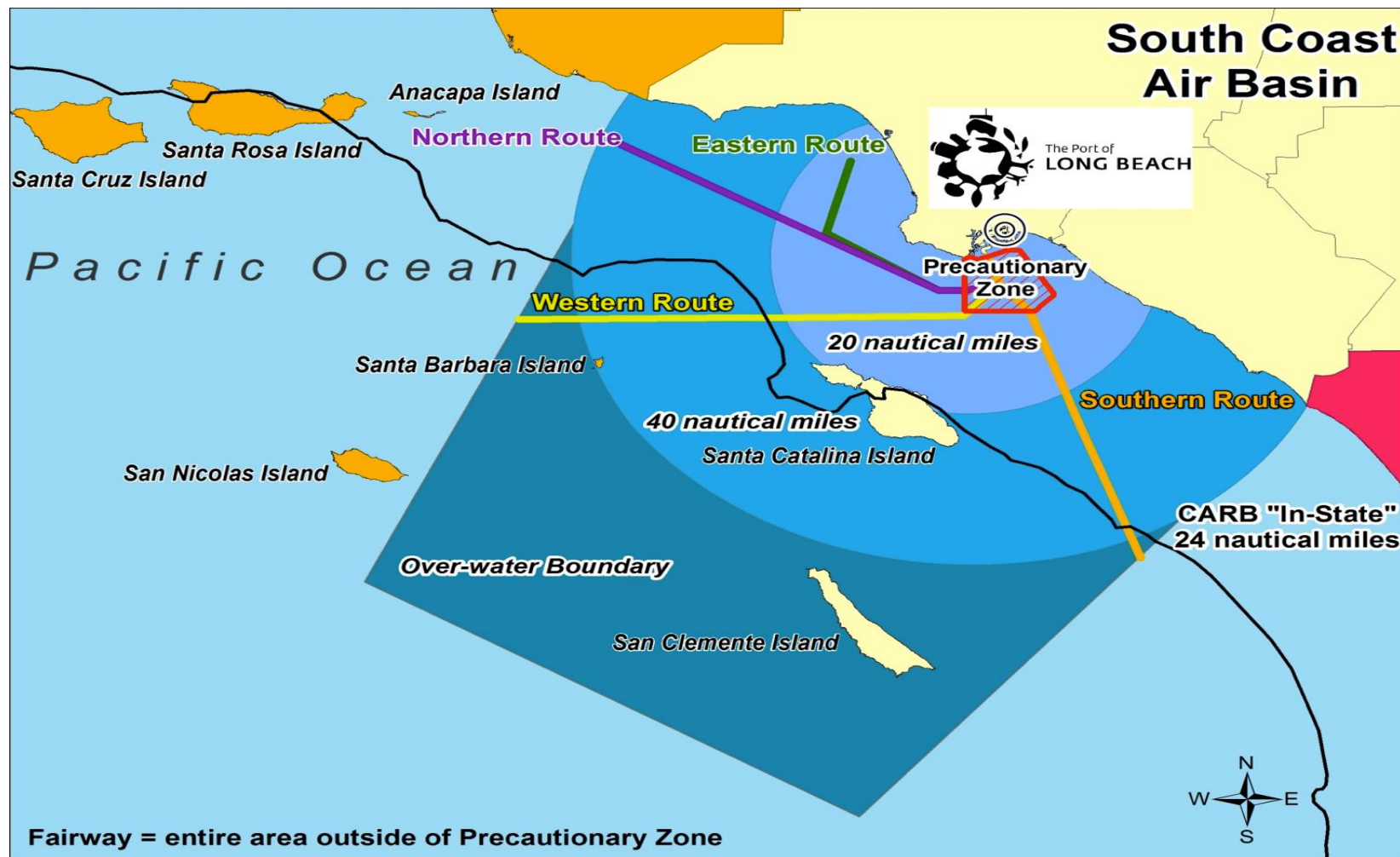
entry/leave fees are discounted

Ship Type	Recommended speed (kts) for port			
	Busan	Ulsan	Yeosu, Gwangyang	Incheon
Container ship	12	12	12	12
General cargo ship	10	-	10	10
Car carrier	12	-	-	-
Crude oil carrier	-	10	-	-
Chemical carrier	-	10	-	-
LNG carrier	-	-	10	10

3. Current Cases for Abating PM

Vessel Speed Reduction(VSR) Program

Case of USA-Los Angeles Port and Long Beach Port



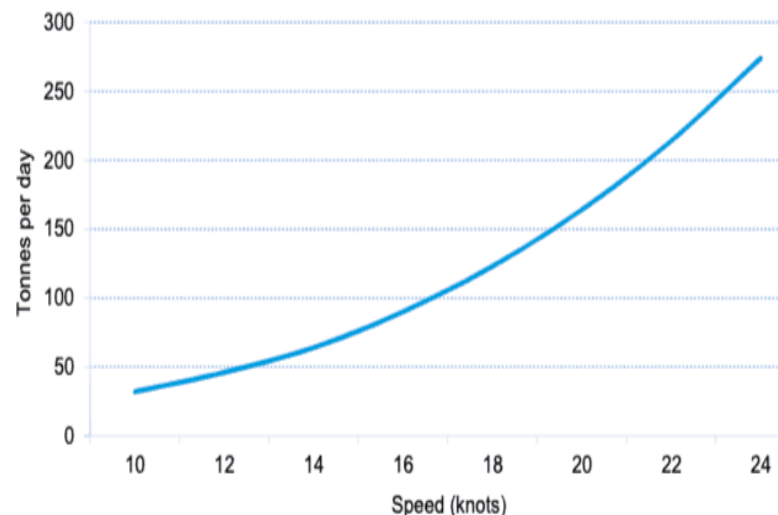
Advantages of VSR

1. Reduces all pollutants
2. All ships can do it
3. Easy to Monitor

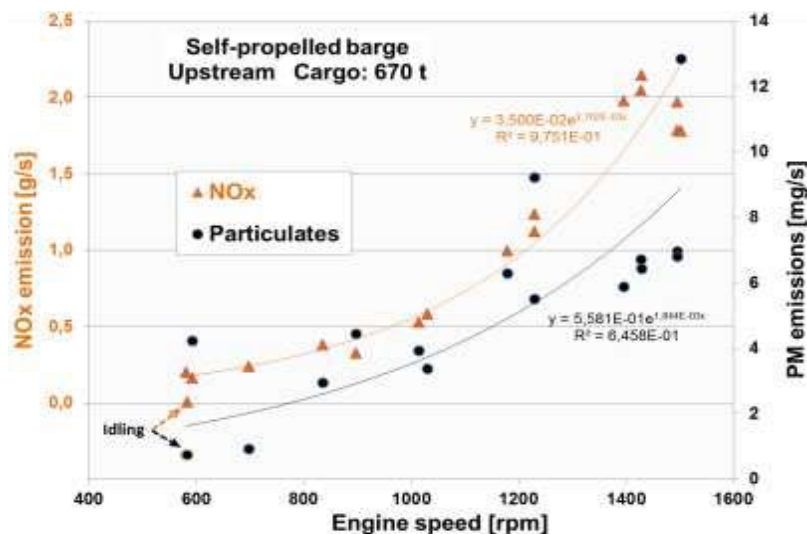
Table ES.3 Emissions Reduction due to VSR

Percent Reduction in Emissions due to VSR					
CO ₂	NO _x [†]	PM _{2.5}	EC	OC	SO ₄ ²⁻ H ₂ O
61	56	69	53	70	75

[†] Note that the 56% reduction in NO_x is attributed to change in fuel (HFO to MGO) and VSR

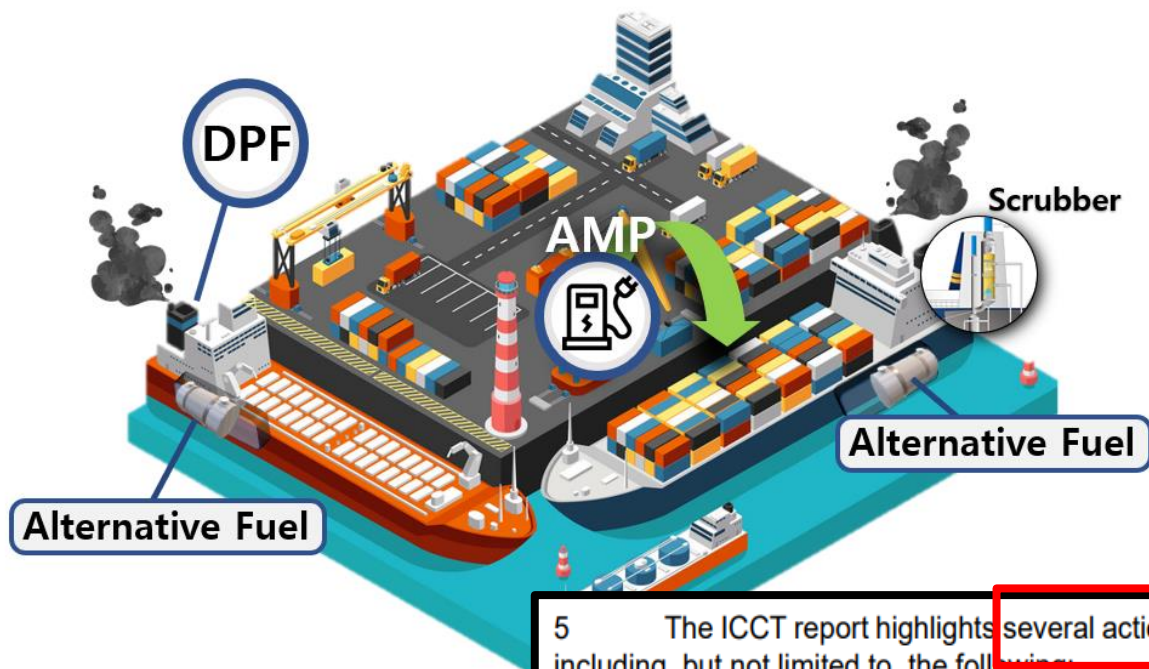


Average fuel consumption of a 14,000-TEU container ship at different speeds



NO_x and PM vs engine speed

3. Current Cases for Abating PM



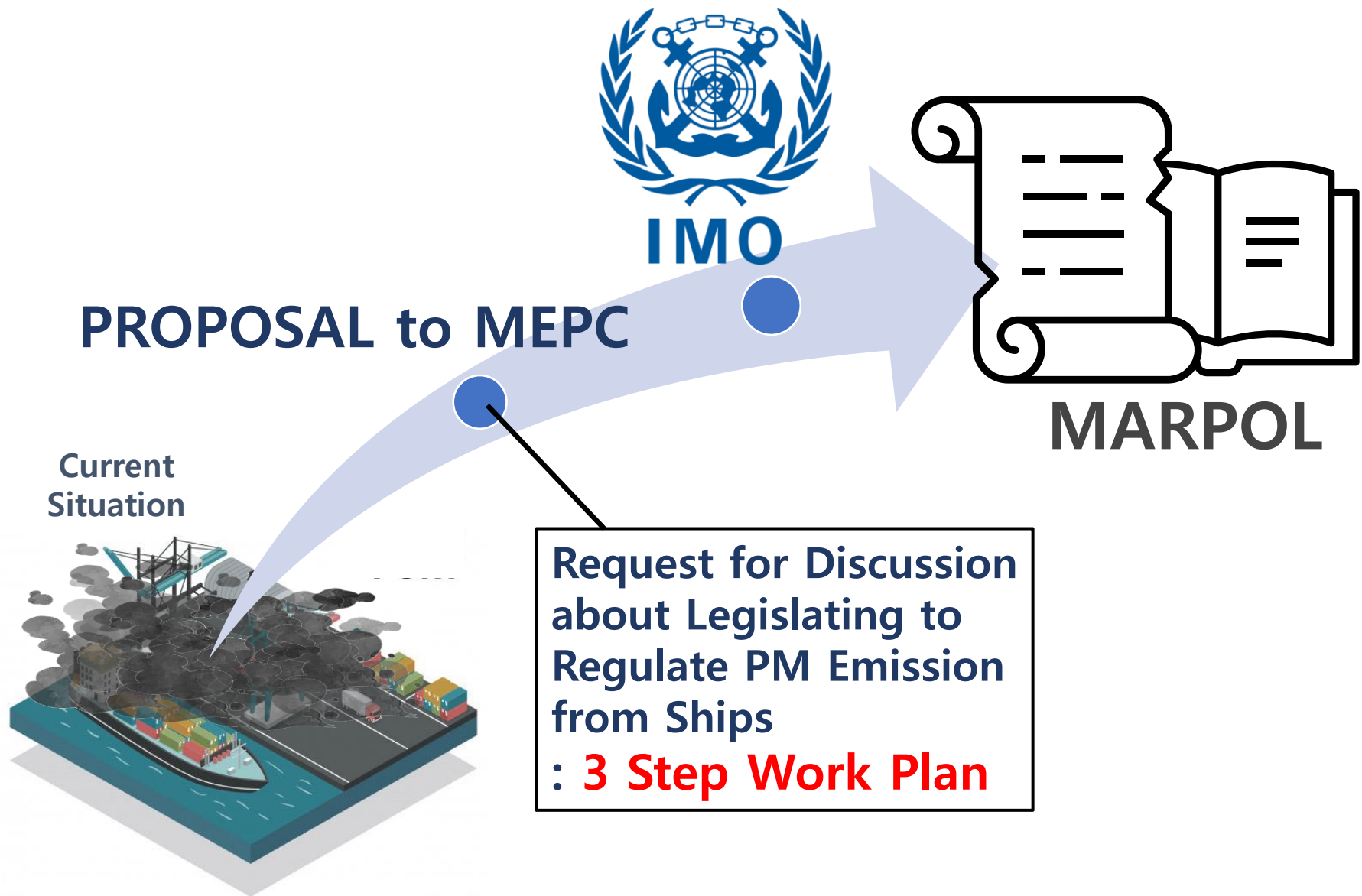
5 The ICCT report highlights several actions that could reduce Black Carbon from ships including, but not limited to, the following:

- .1 prohibit the use of residual fuels, such as heavy fuel oil (HFO), in the Arctic;
- .2 install diesel particulate filters (DPFs) on ships;
- .3 establish Emission Control Areas (ECAs) in heavily trafficked and sensitive areas, including all or portions of the Arctic;
- .4 establish a Black Carbon emission standard for ships;
- .5 include Black Carbon in GHG reduction strategies; and
- .6 make shore power the norm for major ports and major ship classes.

4. Proposal for New Output

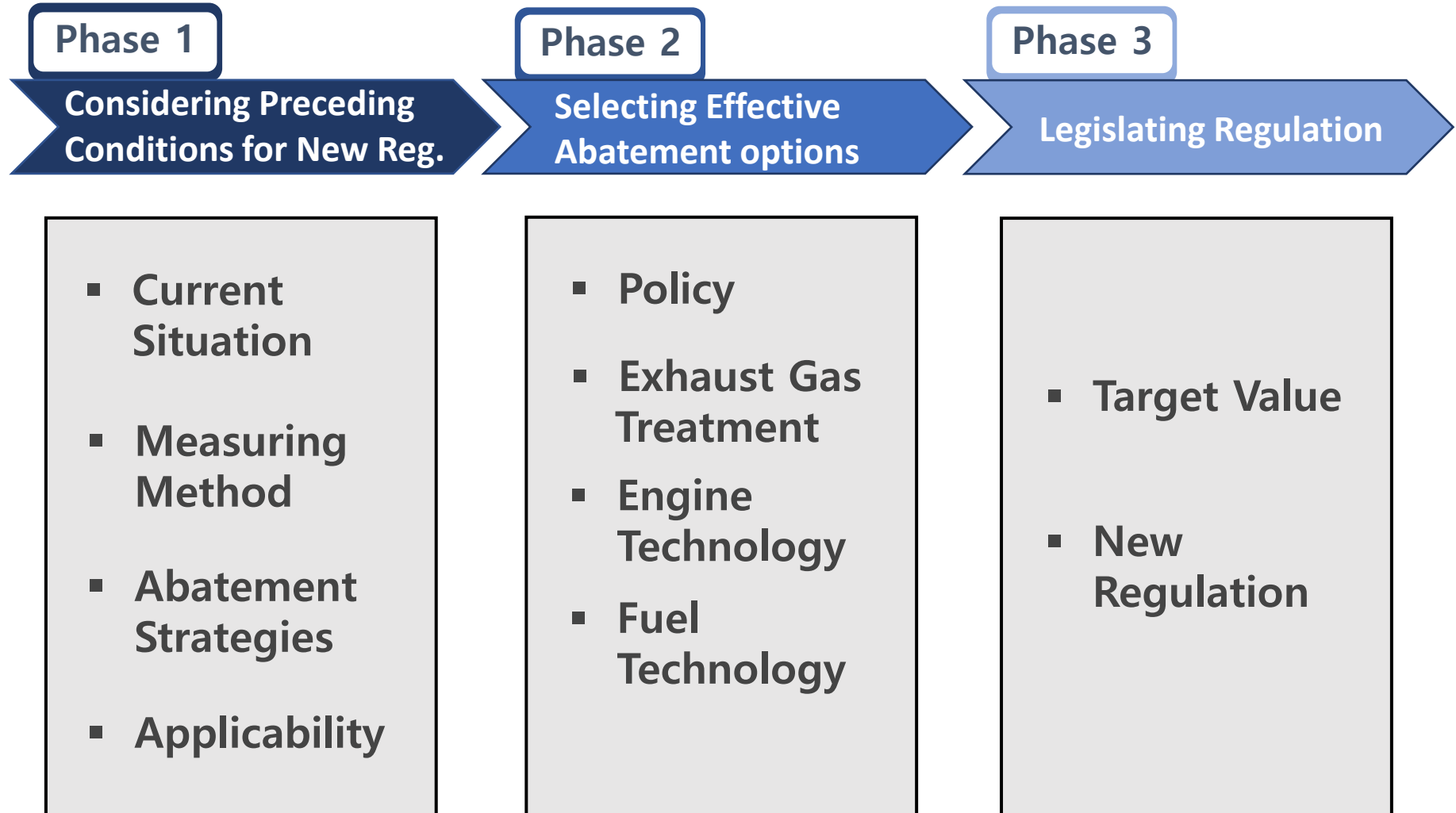


4. Proposal for New Output



4. Proposal for New Output

3 STEP WORK PLAN



4. Proposal for New Output

Phase 1

Considering Preceding
Conditions for New Reg.

Current Situation	Measuring Method	Abatement Strategies	Applicability
<ul style="list-style-type: none"> • Emission • Damage • Discussion 	<ul style="list-style-type: none"> • Measurement considering differences between PM and BC 	<ul style="list-style-type: none"> • Abatement Policy • Abatement Technology 	<ul style="list-style-type: none"> • Difference between Nations <ul style="list-style-type: none"> - Technology Level - Policy Direction • Progress of Technology

4. Proposal for New Output

Phase 2 Selecting Effective Abatement options

Political Option

Establishment of the 'PECA'

- ✓ MARPOL Annex VI Appendix III
- ✓ Where to Establish
 - (Domestic Law O - ex : S. Korea, China)
 - (Domestic Law X – ex : Mediterranean Sea)
- ✓ Regulatory Level
 - based on PM Regulation (Upcoming)

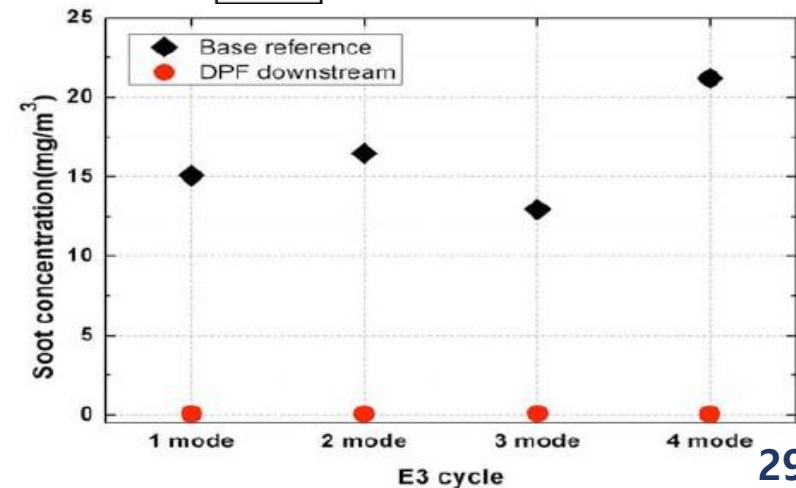
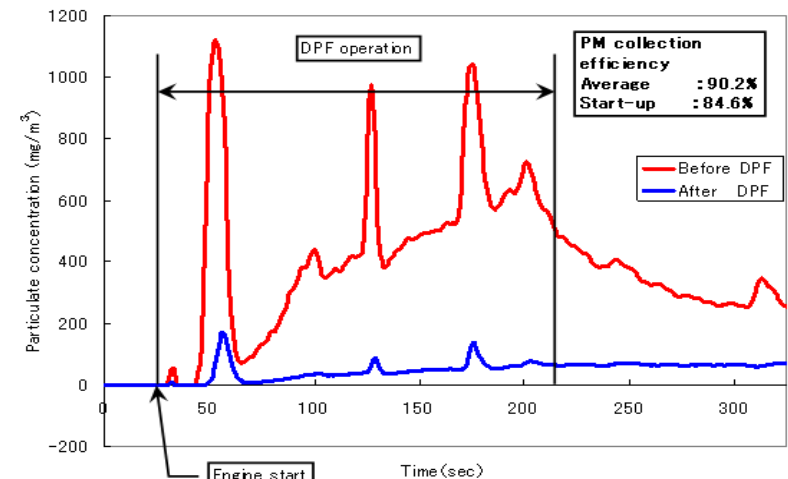
Applying of 'VSRP'

- ✓ Reduction rate of speed
- ✓ VSR Program Zone
- ✓ Speed Monitoring
- ✓ Compensation

Technical Option

DPF(Diesel Particulate Filter)

PM concentrations at vessel departure



4. Proposal for New Output

Phase 3 Legislating Regulation

- Target Value
- New Regulation

“**XX%** Reduction of PM from Ships by **20XX** Globally”

Legislation of an **Independent Regulation that Regulates PM** from Ships.



IMPLEMENTATION



References

#4 <https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM>

#5 - Env. Sci. & Technol., 49, 2015

- 기후변화에 의한 미세먼지 발생과 건강영향 그리고 국제협력_국내IP 환경동향보고

#6 - <https://www.worldatlas.com/what-is-acid-rain.html>

- March 2012 issue of Nature Geoscience., Aron Stubbins

#7 - <https://www.ccacoalition.org/en/slcps/black-carbon>

- Source: Olmer, Comer, Roy, Mao, & Rutherford (2017), submitted as document PPR 5/INF.15

#9 Pollution: Three steps to a green shipping industry

2016S.P. SinghNature News & Comment

#10 Mingliang Fu et al 2017 Environ. Res. Lett. 12 114024

#11 국립환경과학원, 국가 대기오염물질 배출량 서비스(<http://airemiss.nier.go.kr>)의 통계 재편집 및 작성

#12 Global-Marine-BC-Inventory-2015_ICCT-Report

#12 Prevalence of heavy fuel oil and black carbon in Arctic shipping, 2015 to 2025 BRYAN COMER, NAYA OLMER, XIAOLI MAO, BISWAJOY ROY, DAN RUTHERFORD MAY 2017

#13 - 국립환경과학원 연도별 배출량 통계(2014)

- 국립환경과학원, 국가 대기오염물질 배출량 서비스(<http://airemiss.nier.go.kr>)의 통계(2015)

#15 Note by the International Maritime Organization to the UNFCCC Talanoa Dialogue

#17 - Mingliang Fu et al 2017 Environ. Res. Lett. 12 114024

- (Marine engine emission standards for China's domestic vessels | International Council on Clean Transportation, 2020)

#18 & 21 (MINISTRY OF OCEANS AND FISHERIES>What's New - VESSEL SPEED REDUCTION(VSR) PROGRAM TO START DECEMBER THIS YEAR, 2020)

#19 <https://chinadialogueocean.net/8054-curbing-deadly-shipping-emissions/>

#20 - ICCT_COSTS AND BENEFITS OF A PEARL RIVER DELTA EMISSION CONTROL AREA

- <https://www.euractiv.com/section/shipping/opinion/a-roadmap-to-cut-shipping-emissions-in-the-mediterranean/>

- US EPA

#22 THE PORT OF LOS ANGELES_Vessel Speed Reduction Incentive Program Guidelines

#23 Drewry / HAL / California Air Resources Board

#29 Mitsui O.S.K. Lines. 2020. MOL Develops Marine Use Diesel Particulate Filter | Mitsui O.S.K. Lines.

#29 선박배출대기오염원(PM/BC) 기후변화 영향평가 및 저감기술개발 최종보고서, 해양수산부, 해양수산과학기술진흥원

Thank you

Question