Washwater discharge from open-looped SOx scrubber system

19/2/2019

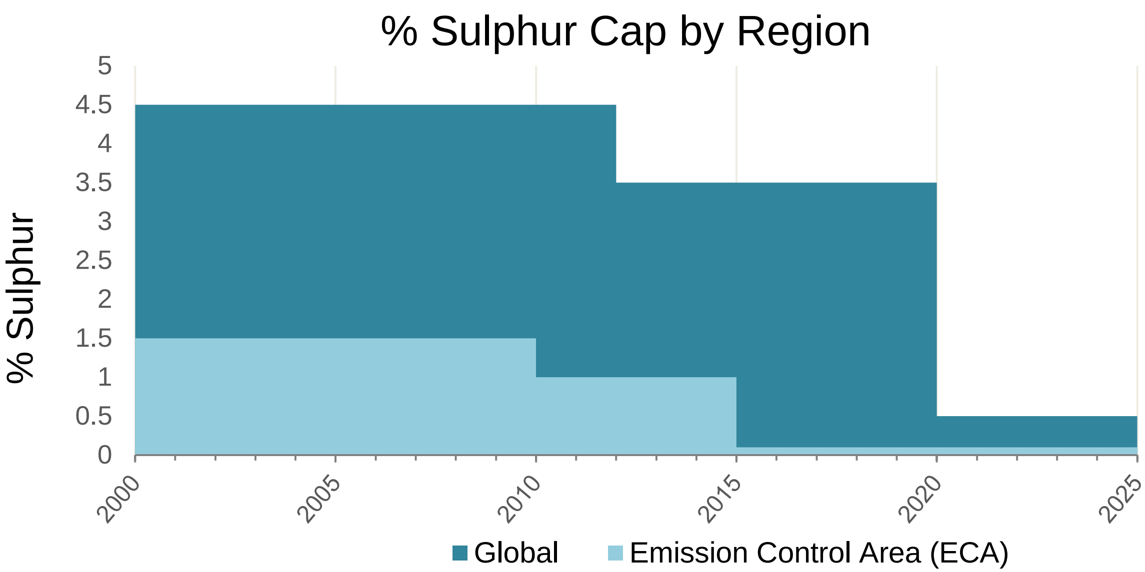
Ministry of Land, Infrastructure, Transport and Tourism (MLIT), JAPAN

Outline

1. Introduction
2. Basic understandings of the risks to human health and marine environment by SOx emission
3. Investigation on the effects of discharged water from scrubber
4. Conclusion

1. Introduction

International Regulation and Possible Solutions



MARPOL Annex VI Regulation 14
Sulphur Oxides and Particulate Matter (SOx & PM)

3.5% High-Sulphur Fuel Oil (HSFO)

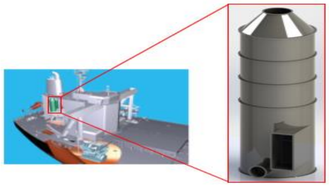
Low sulfur fuel oil

- 0.5% bunker fuel oil
- Marine Gasoil (MGO)

LNG-fuelled ship

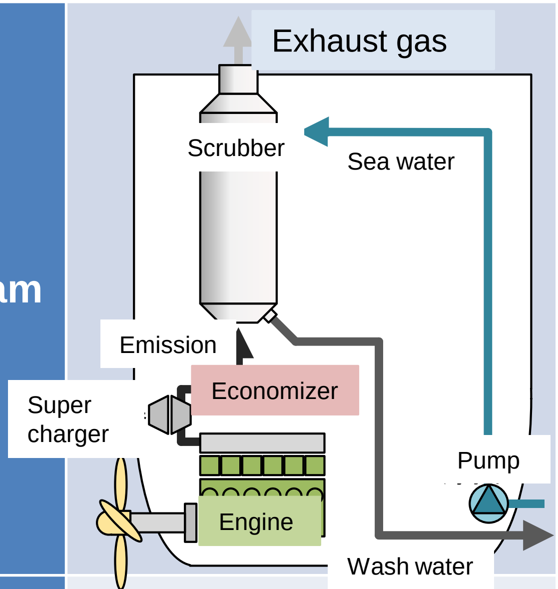
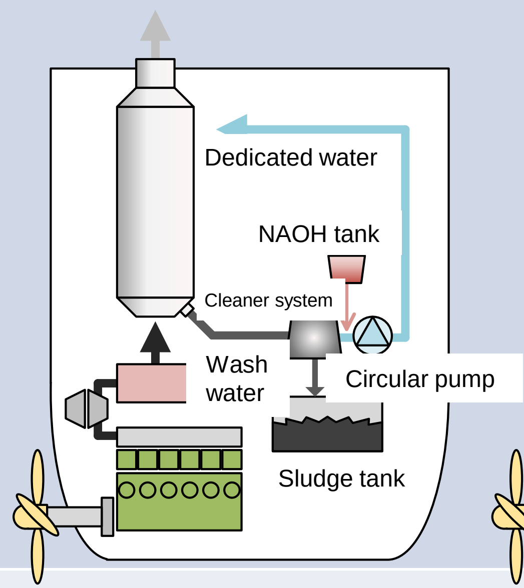
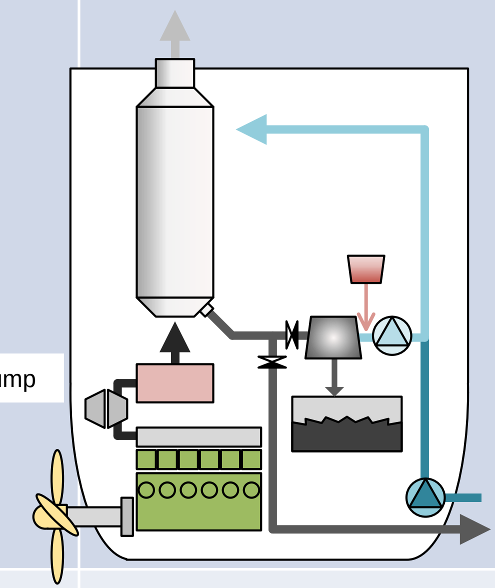
PM, NOx and CO2 can also be reduced

Scrubber (EGCS)



Enable to use 3.5% HSFO

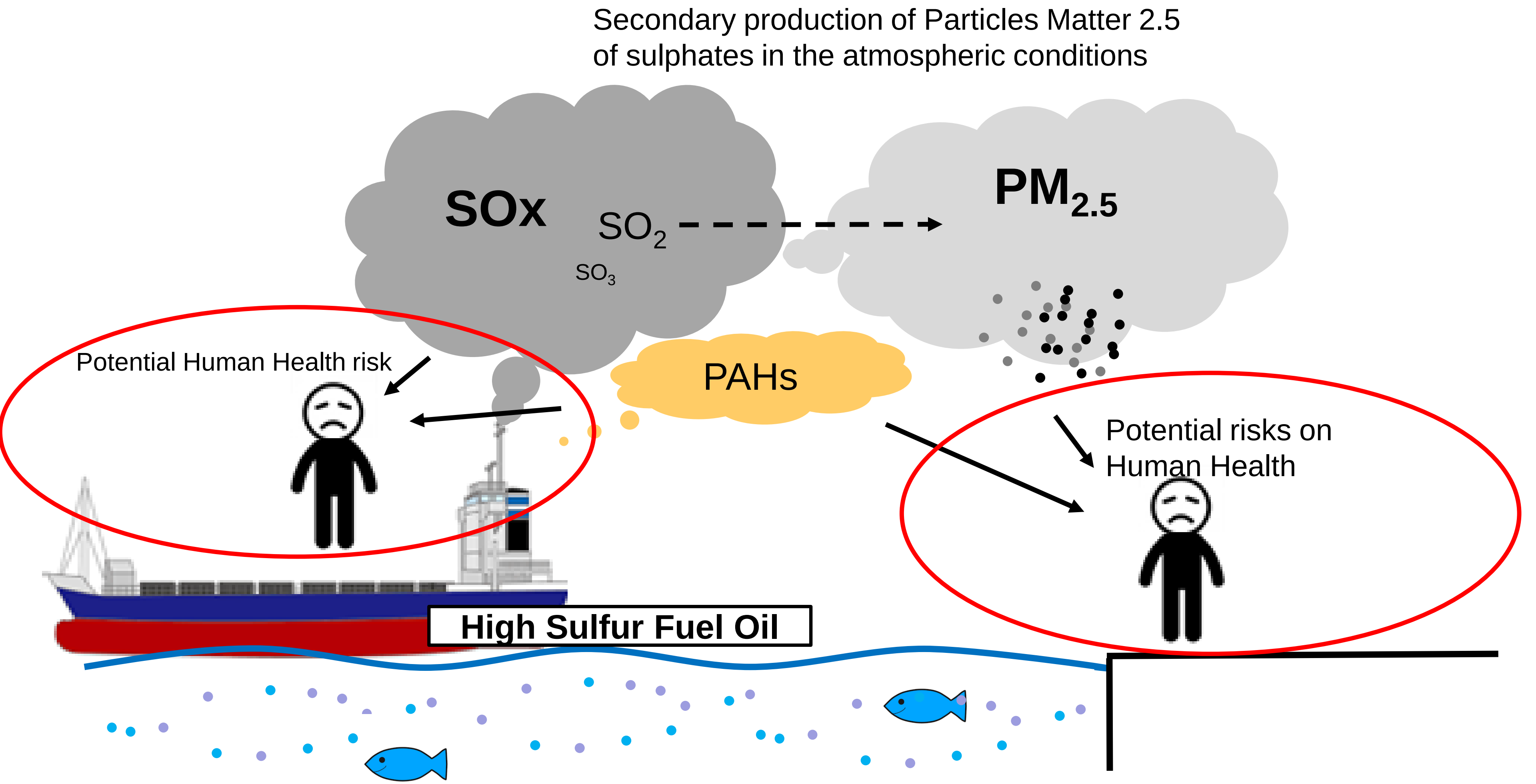
Characteristics of Scrubber

	Open-Looped	Closed-Looped	Hybrid
Diagram			
Wash water	Sea water	Dedicated water (usually fresh water)	Sea water or dedicated water
Characteristics	• Simple device • Discharge water	• More complicated system than open type • Few discharge water	• Enable to switch between open and closed mode

2. Basic understandings of the risks to human health and marine environment by SOx emission

Basic understanding of the risks to Human Health and Marine Environment by SOx emission

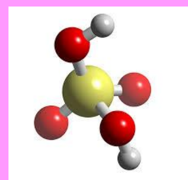
Before Sulphur reduction



the risks to Human Health

SOx

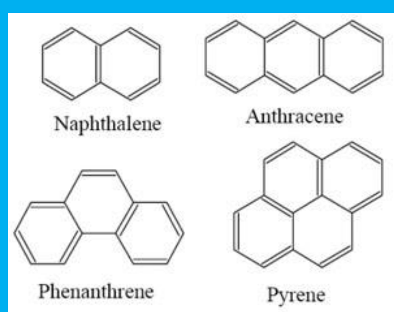
$PM_{2.5}$

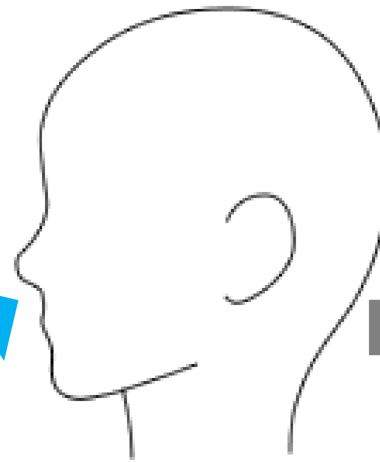


H_2SO_4

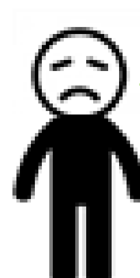
$(NH_4)_2SO_4$

PAHs





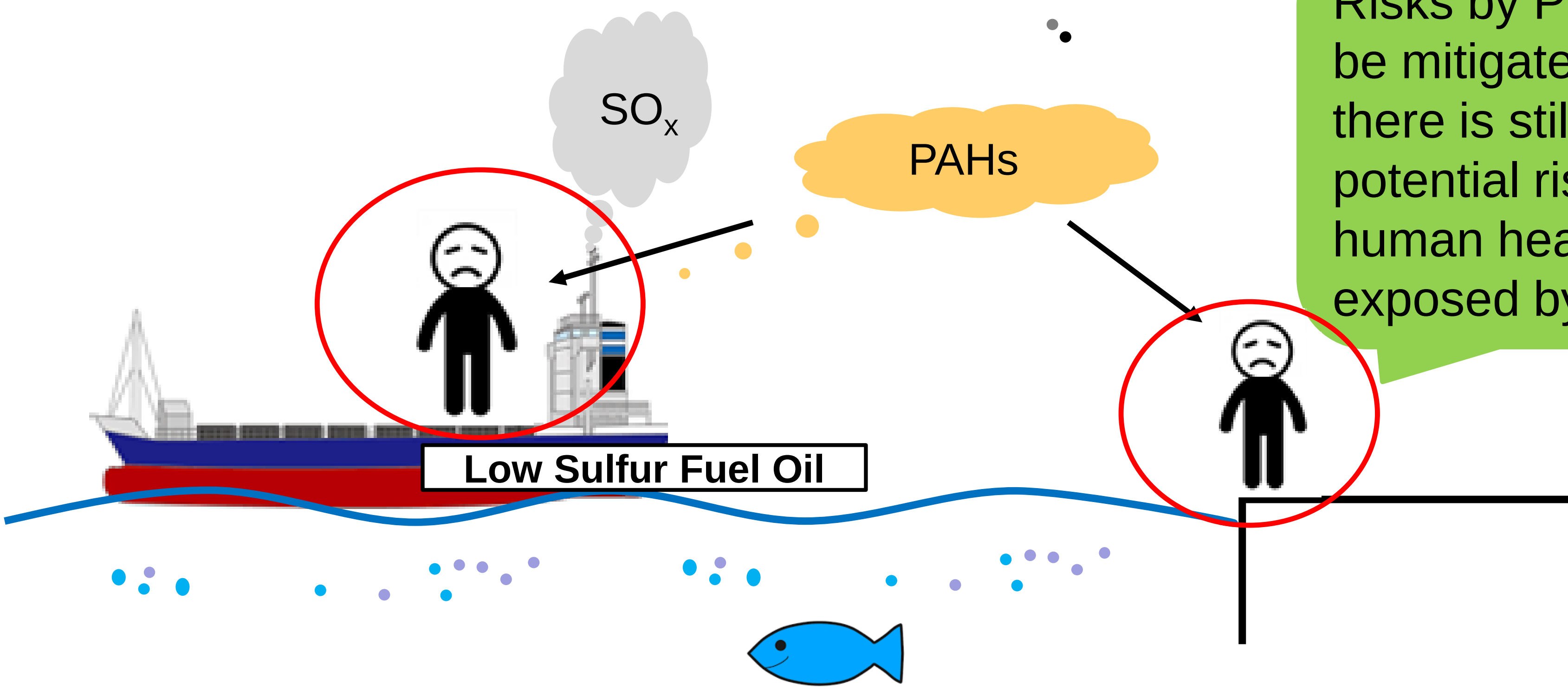
- Disease of respiratory system and circulatory (cardiovascular) system
- Skin and Eyes irritation/corrosion etc.



The more emission, the higher risk to human health

After Sulphur reduction with **Low sulphur fuel oil**

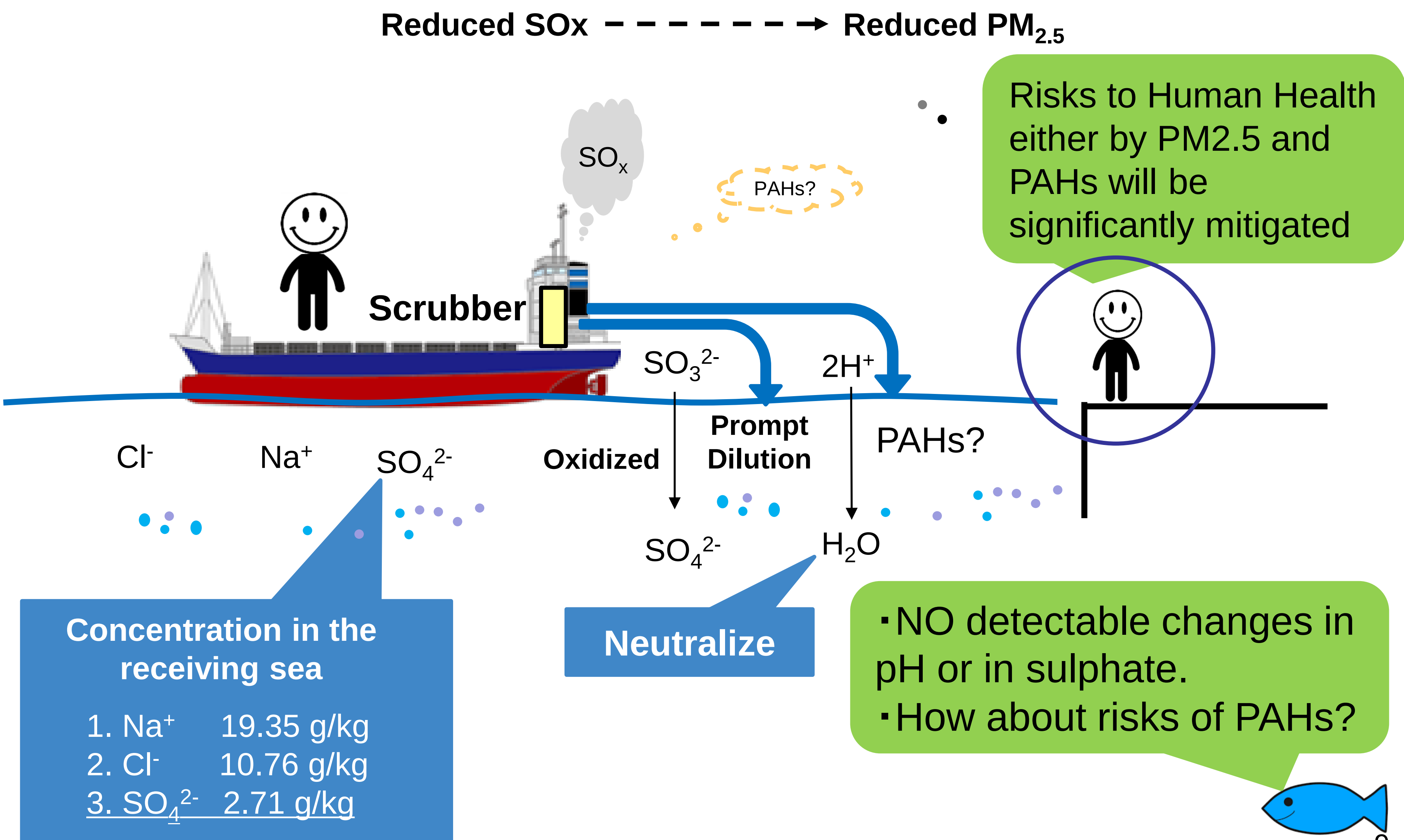
Reduced SOx - - - - - -> **Reduced $PM_{2.5}$**



Risks by PM2.5 will be mitigated **but** there is still potential risk to human health exposed by **PAHs**

Basic understanding of the risks to Human Health and Marine Environment by SOx emission

SOx, PM (and others) emission reduction by **Open-looped scrubber**



3. Investigation on the effects of discharged water from scrubber

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Simulation for Dilution of discharged water from stern

■Using CFD model, the strength of the turbulent flow with vortex (swirls) behind the hull of Panamax (82,000 DWT) was estimated, and then theoretical dilution rate was calculated.

■The worst cased discharge water flow from scrubber (main engines operated at MCR) is assumed for this simulation.

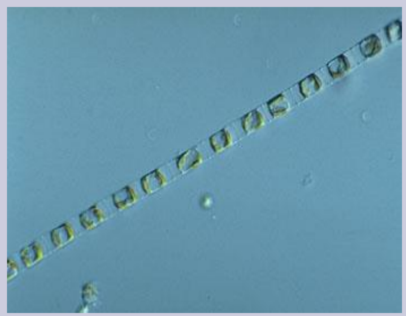
Result . The calculated dilution rate, according to the duration time after discharge

Duration time(sec)	0.1	0.2	0.3	2.6	5.3	7.4	59.5	108.1	129
dilution rate	40	60	80	500	800	1,000	5,000	8,500	9,661

- The time to reach 500 folds dilution is estimated around 3 seconds after its discharge.
- The time to reach 5,000 folds dilution is estimated about 1 minute after its discharge.

The risk on marine organisms

The result of Whole Effluent Toxicity (WET)

	Algae (micro algae)	**Invertebrates (crustacean)**	**Vertebrate (fish)**
	diatom (Skeletonema costatum) 	Ptilohyale (Hyale barbicornis) 	Adrianichthyidae (Oryzias javanicus) 
Acute endpoint	49% (EC 50)	<u>20%</u> <u>(5 folds dilution)</u> (LC 50)	35% (LC 50)
Exposure time	72 hours	96 hours	96 hours

LC: Lethal Concentration
EC: Effect Concentration

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Assignment of Assessment Factors(AF) used for deriving PNEC values

(Methodology for information gathering and conduct of work of the GESAMP-BWWG)

Data-set	Assessment Factor	
	PNEC general	PNEC near ship
Lowest short-term LC50 from freshwater or marine species representing one or two trophic levels	10,000	1,000
Lowest short-term LC50 from three freshwater or marine species representing three trophic levels	1,000	100
Lowest short-term LC50 from three freshwater or marine species representing three trophic levels + at least two short term LC50 from additional marine taxonomic groups	100	10
Lowest chronic NOEC from one freshwater or marine species representing one trophic level, but not including micro-algae	100	
Lowest chronic NOEC from two freshwater or marine species representing two trophic levels, which may include micro-algae	50	
Lowest chronic NOEC from three freshwater or marine species representing one trophic level, but not including micro-algae	10	

The reasons for the assessment facto of 1000 are;
10 for conversion from acute to chronic
10 for cancelling the differed sensitivity among species
10 for conversion from LC50 to PNEC

PNEC general：long-term PNEC
PNEC near ship：short-term PNEC
LC50：Lethal Concentration 50%

The risk on marine organisms

LC 50 dilution rate		PNEC near ship (short term)		Safety dilution rate (short-term)
20% (1/5)	×	1/100	=	1/500
		PNEC general (long-term)		Safety dilution rate (long-term)
		1/1000	=	1/5000

- The time to reach the dilution rate of 500 folds dilution is estimated around 3 seconds (see slide 12) after its discharge.

Any-short term adverse effects could not be expected because possible exposure time is significantly shorter than that of WET (ie. 96 hours, as shown in slide 12).

- The time to reach the dilution rate of 5,000 folds dilution is estimated about 1 minute (see slide 12) after its discharge.

Any-long term adverse effects could not be expected because the dilution and diffusion will be continued.

Japan concluded that either any short- or long-term effects on marine organisms cannot be caused by the use of open-looped scrubber.

The impact on the seawater quality

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1. Targeted substances for the prediction of long-term concentration

pH, Nitrate, and Chemical oxygen demand (COD) are selected by the screening process for the simulations

Substances analyzed		Unit	Discharge water
PAH	Naphthalene	µg/L	0.006
	2-methylnaphthalene	µg/L	0.006
	1-methylnaphthalene	µg/L	<0.01
	Biphenyl	µg/L	<0.005
	Acenaphthylene	µg/L	<0.005
	Acenaphthene	µg/L	<0.005
	Fluorene	µg/L	<0.005
	Dibenzothiophene	µg/L	<0.005
	Phenanthrene	µg/L	0.006
	Anthracene	µg/L	<0.005
	Fluoranthene	µg/L	<0.005
	Pyrene	µg/L	0.007
	Benz[a]anthracene	µg/L	0.006
	Chrysene	µg/L	<0.005
	Benzo[b]fluoranthene	µg/L	0.012
	Benzo[k]fluoranthene	µg/L	<0.005
	Benzo[a]pyrene	µg/L	0.014
	Perylene	µg/L	<0.005
	Indeno[1,2,3-cd]pyrene	µg/L	<0.005
	Dibenz[a,h]anthracene	µg/L	0.006
	Benzo[ghi]perylene	µg/L	0.014

The amount of detected PAHs respectively was only slightly above their detection limits

Substance	unit	Actual Concentration of heavy metal	Discharge criteria for onland sources
Vanadium	µg/L	58	No criterion
Nickel	µg/L	17.9	No criterion
Iron	µg/L	997	10000
Zink	µg/L	48.3	2000
Lead	µg/L	1.755	100
Cupper	µg/L	8.12	3000
Cadmium	µg/L	0.035	30
Chrome	µg/L	22.8	2000
Arsenic	µg/L	1.02	100

The actual amount of heavy metals in the discharge water from scrubber were substantially less than the emission standard for on land sources in Japan, by order of 100.

2. Selected sea areas for prediction of long-term concentration

Seto sea, Ise sea and Tokyo Bay were selected in terms of their enclosed conditions and ship congestion

3. Condition for the prediction

10 years accumulated concentration of the substances under the worst-cased scenario(※) were estimated.

(※) All ships in these areas will be equipped with open-looped scrubber and will discharge the wash water

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Results of the calculation of the concentration for 10 years and comparison with the actual concentration as of 2015

Item	Additional Accumulated concentration after 10 years		
	Tokyo Bay	Ise Bay	Seto Inland Sea
pH	NO changes (※) (current rage pH 8.3)	NO changes (※) (current rage pH 8.2)	NO changes (※) (current rage pH 8.1)
Nitrate-nitrogen (mg/L)	7.34×10^{-4} (current rage 0.27-0.74)	5.30×10^{-5} (current rage 0.29-0.54)	2.01×10^{-3} (current rage 0.14-0.71)
COD(mg/L)	3.85×10^{-4} (current rage 2.2-2.9)	8.11×10^{-7} (current rage 2.4-3.5)	9.62×10^{-4} (current rage 1.8-2.7)

※ The pH changes caused by the accumulated concentration of sulphates ion and nitrates ion is less than 0.0035.

The accumulated concentration by the concerned substances in wash water is less than the current concentration in the respective target areas, by order of 100.

(In case only 5% of the ships are installed with scrubbers, the accumulated concentration is less by order of 2000.)

Conclusion

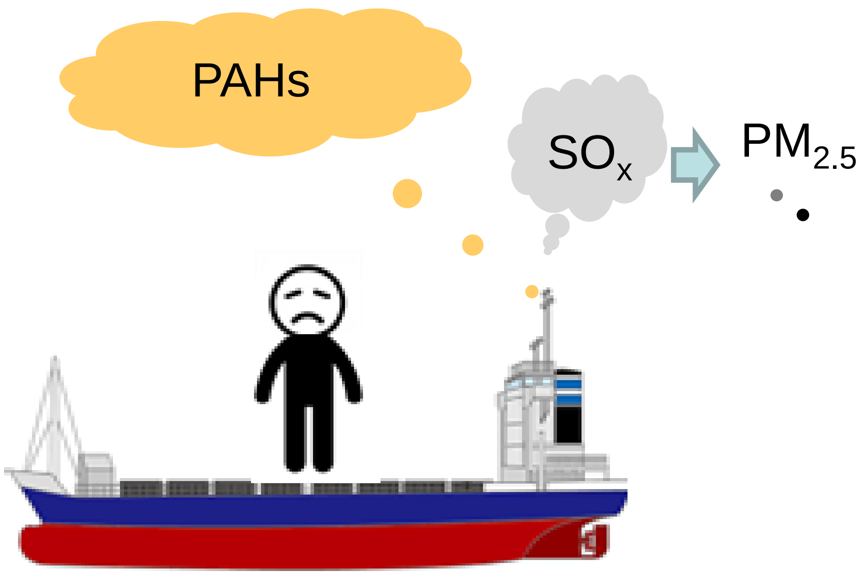
- **Scrubbers enable to mitigate potential risks to human health by reducing harmful substances; not only SOx and PM, but also PAHs and other materials that would otherwise be emitted into the atmospheric air.**

- **Japanese government assessed the potential risks to marine environment by discharged water from scrubber.**

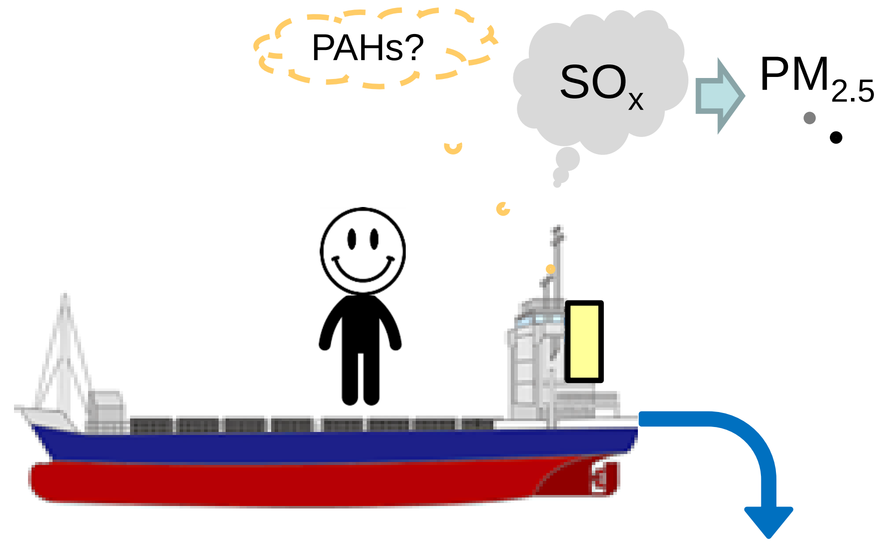
- **Japan concluded that the discharge water with chemical substances such as SOx, PAHs and heavy metals can NOT cause unacceptable effects either on the marine organisms or on the seawater quality around Japan.**

- **Therefore, Japan is of the position that there would NOT be a scientific justification to prohibit the use of open-looped scrubber, as long as the IMO's discharge criteria were met.**

Which is better?



Sulphur 0.5% Fuel Oil
WITHOUT Scrubber



Sulphur 3.5% Fuel Oil
WITH Scrubber

H^+
SO_4^{2-}
PAHs?
etc