Size-segregated characteristics of OC, EC and organic matters in PM emitted from different types of ships in China

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Table S1 Technical parameters of test vessels

Vessel ID	Engine power (kW)	Vessel type	Length × width (m)	Material	Vessel age（year）	Rated speed (rpm)	Engine type	Fuel type	Classified Type
GB1	91	Gillnet	20×4.3	Wooden	10	1500	4-stroke	Diesel	4-LDF
GB2	178	Gillnet	27×5.6	Wooden	7	1500	4-stroke	Diesel	
AB1	129	Angling boat	21×4.3	Wooden	6	1500	4-stroke	Diesel	
AB2	176	Angling boat	22.7×4.8	Wooden	5	1800	4-stroke	Diesel	
TB1	88	Trawler	13×3.5	Wooden	8	1500	4-stroke	Dieselc	
TB2	132	Trawler	13×3.5	Wooden	5	1500	4-stroke	Diesel	
TB5	265	Trawler	29×5.4	Metal	10	1800	4-stroke	Diesel	
TB6	265	Trawler	29×5.4	Metal	10	1800	4-stroke	Diesel	
HH	350×2	Engineering vessel	44×13	Metal	4	1200	4-stroke	Marine Diesel	4-HMV
DFH	1600×2	Research vessel	96×15	Metal	18	900	4-stroke	Marine Diesel	
XYH	600	Research vessel	55×9	Metal	5	1000	4-stroke	Marine Diesel	
YK	4440	Training vessel	116×18	Metal	11	173	2-stroke	HFO	2-HHV

Table S2 Results of the fuel quality analysis

Vessel ID	Carbon (C) %	Hydrogen (H) %	Oxygen (O) %	Nitrogen (N) %	Sulfur (S) %	Gross calorific value MJ/kg	Net calorific value MJ/kg	Kinematical viscosity (40℃) mm^2/s
GB1	85.96	12.76	<0.3	0.49	0.022	45.83	42.79	4.517
GB2	86.09	12.67	0.6	0.61	0.169	45.32	42.41	2.639
AB1	86.35	12.73	<0.3	0.49	0.111	45.79	42.75	2.430
AB2	85.72	12.73	<0.3	0.49	0.046	45.42	42.48	2.782
TB1/TB2	86.21	11.50	2.03	0.05	0.066	45.01	42.42	4.125
TB5/TB6	85.92	12.49	<0.3	0.41	0.284	45.26	42.37	2.646
HH	86.66	13.32	< 0.4	< 0.2	0.080	45.44	42.51	N.A.
DFH	86.40	13.22	< 0.4	< 0.2	0.046	45.40	42.48	N.A.
XYH	86.49	13.44	< 0.4	< 0.2	0.130	45.50	42.55	N.A.
YK	84.12	10.38	4.26	0.79	0.448	43.50	41.10	N.A.

N.A., Not Analyzed.

Table S3 Size-resolved particle samples collected in this study

Vessel ID	Operating mode	Quantity	Dilution ratio	Vessel ID	Operating mode	Quantity	Dilution ratio
YK	Manoeuvering	2	1.7-1.8	TB5	Trawling	1	2.8
	Cruise	3	2.2-2.6	TB6	Trawling	1	2.1
GB1	Placing/drawing in net	1	4.2		High speed	1	2.4
	cruise	1	3.6	HH	Low speed	1	1.0
GB2	Idling	1	2.6		Cruise	2	1.0
	High speed	1	2.8	XYH	Idling	1	1.0
AB1	High speed	1	3.0		Cruise	1	1.0
AB2	Idling/angling	2	2.8-3.0	DFH	Idling	1	1.0
TB1	Idling	1	2.0		Acceleration	2	1.0
	Medium speed	1	2.0		Cruise	1	1.0
TB2	Idling	1	2.0				
	Medium speed	1	2.0				

Table S4 Particle size fractions of 8 Stage Andersen Cascade Impactor

Stage	Particle size range (μm)	Sampling spot number
0	>9.0	96
1	5.8-9.0	96
2	4.7-5.8	400
3	3.3-4.7	400
4	2.1-3.3	400
5	1.1-2.1	400
6	0.65-1.1	400
7	0.43-0.65	201
8	<0.43	--

--, the sampling area in this stage is a circle with diameter of 7.94 cm.

Table S5 16 priority PAHs and their abbreviations

	Abbreviation	Number of rings
Napthalene	Nap	2
Acenaphthylene	Acy	2
Acenaphthene	Ace	2
Fluorene	Flu	3
Phenanthrene	Phe	3
Anthracene	Ant	3
Fluoranthene	Flua	4
Pyrene	Pyr	4
Benzo[a]anthracene	BaA	4
Chrysene	Chr	4
Benzo[b]fluoranthene	BbF	5
Benzo[k]fluoranthene	BkF	5
Benzo[a]pyrene	BaP	5
Indeno[1,2,3-cd]pyrene	IcdP	6
Dibenzo[a,h]anthracene	DahA	5
Benzo[ghi]perylene	BghiP	6

Table S6 average recoveries of the deuterium surrogates

D-PAHs	Average recovery±SD	D-n-alkanes	Average recovery±SD
D8- Naphthalene	84.3±10.5	D-C16	95.0±7.48
D10- acenaphthene	101±11.8	D-C20	96.1±14.2
D10- phenanthrene	99.5±8.24	D-C24	97.2±15.5
D12- chrysene	95.1±14.2	D-C30	92.0±14.9
D12-perylene	84.8±16.4		

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Table S7 OC and EC distributions in different particle size bins (%)

	Particle size (μm)	2-HHV	4-HMV	4-LDF
OC	<0.43	74.7±4.84	22.9±11.2	42.6±14.6
	0.43-0.65	7.10±1.80	15.9±3.52	21.5±9.64
	0.65-1.1	4.61±1.55	14.0±2.93	9.62±2.50
	1.1-2.1	3.48±1.56	11.0±2.23	7.12±3.52
	2.1-3.3	3.18±1.91	8.73±2.27	4.96±3.19
	3.3-4.7	2.24±0.67	8.39±2.67	4.89±3.50
	4.7-5.8	2.15±0.87	9.42±5.83	4.85±3.78
	5.8-9.0	1.34±0.63	3.99±0.94	2.08±1.50
	>9.0	1.18±0.55	5.64±2.32	2.33±1.87
EC	<0.43	65.9±9.87	27.3±8.86	31.7±13.3
	0.43-0.65	14.7±6.65	22.0±6.50	32.2±11.1
	0.65-1.1	6.93±1.76	18.8±5.37	14.2±6.11
	1.1-2.1	3.71±1.68	16.3±5.59	9.10±4.58
	2.1-3.3	1.99±2.42	4.92±2.99	4.15±2.29
	3.3-4.7	2.14±2.08	3.45±2.08	3.18±2.90
	4.7-5.8	2.09±1.89	2.03±1.98	3.30±3.22
	5.8-9.0	1.86±2.47	1.02±0.93	1.16±1.21
	>9.0	0.71±0.67	4.22±6.24	1.07±0.88

Table S8 The distribution of total PAHs and total n-alkanes in different particle size bins (%)

	Particle size (μm)	2-HHV	4-HMV	4-LDF
PAHs	<0.43	78.6±2.78	37.6±12.8	59.5±13.1
	0.43-0.65	4.90±1.54	14.7±8.72	16.4±6.56
	0.65-1.1	4.51±0.81	14.0±6.65	10.1±4.51
	1.1-2.1	2.32±1.48	10.9±7.14	5.56±3.49
	2.1-3.3	3.22±1.43	7.52±3.49	2.91±2.45
	3.3-4.7	2.27±1.88	5.22±2.26	2.10±1.76
	4.7-5.8	3.12±0.75	5.58±2.76	1.58±2.05
	5.8-9.0	0.49±0.28	1.97±1.55	0.72±0.90
	>9.0	0.55±0.25	2.47±3.94	1.11±2.10
N-alkanes	<0.43	90.2±2.99	54.4±23.5	51.0±17.2
	0.43-0.65	2.05±0.77	11.9±6.47	16.1±7.05
	0.65-1.1	2.35±0.79	12.7±8.51	16.5±11.9
	1.1-2.1	1.39±0.83	7.20±6.47	7.07±4.71
	2.1-3.3	1.28±0.43	5.65±8.00	3.25±2.60
	3.3-4.7	0.80±0.74	2.96±3.42	2.80±3.30
	4.7-5.8	1.25±0.44	3.27±4.07	2.07±2.26
	5.8-9.0	0.32±0.07	0.87±1.38	0.54±0.49
	>9.0	0.40±0.09	1.02±1.57	0.74±1.00

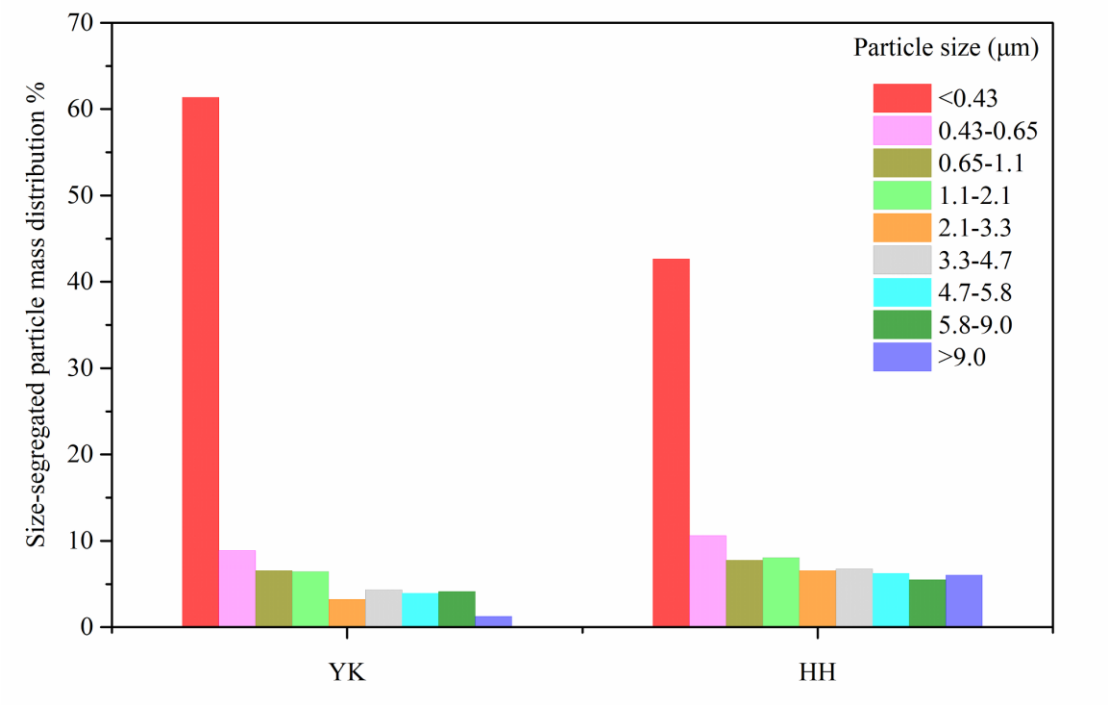

Figure S1 Size-segregated particle mass distribution of auxiliary engines

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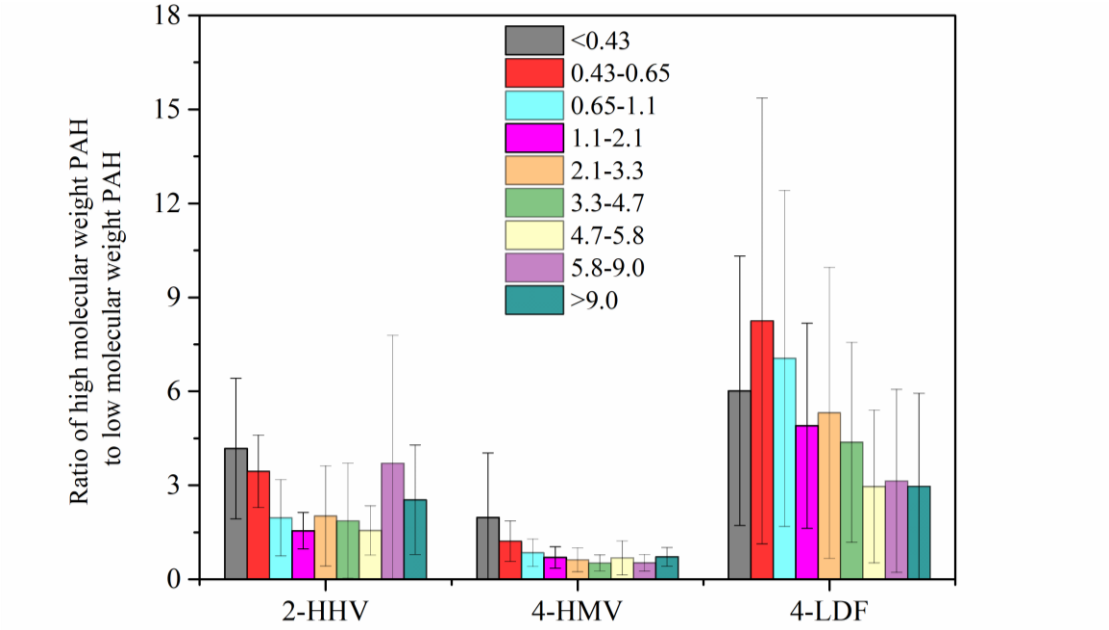

Figure S2 Ratio of high molecular weight PAH to low molecular weight PAH