Hong Kong Study on Marine Vessels Emission Inventory

Simon K W NG
Ben LIN

Institute for the Environment, HKUST

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Outline of Presentation

- Background
- Objective and Scope of Study
- Methodology
- Data Collection
- Base Year Emission Inventory 2007
- Historical Emission Inventory 1990-2006
- Projected Emission Inventory 2008-2020
- Discussion and Conclusion

Background (1/4)

- Emission trends
  - Emission of key air pollutants from major sources has recorded gradual reduction since 1990. The marine sector is an exception.

Air Pollutant Emissions in Percentage Change by Major Source, 1990 - 2007

Source	Sulphur Dioxide	Nitrogen Oxides	Particulate Matters
Power Generation	↓49%	↓67%	↓69%
Road Transport	↓95%	↓22%	↓64%
Marine	↑93%	↑84%	↑61%
Civil Aviation	↑155%	↑156%	no change
Other Fuel Combustion	↓65%	↓27%	↓35%
Non-combustion	N/A	N/A	↑19%
Total	↓51%	↓48%	↓55%

Source: HKEPD (1/2009)

Background (2/4)

- Health implications
  - Bunker fuel/marine fuel oil (max. 4.5% sulphur (S)) burnt by ocean-going vessels is thousands of time higher in sulphur content than fuel used by vehicles (0.005% S for ULSD; 0.001% S for Euro V diesel), leading to higher SO_2 and PM_{10} emissions.
  - Studies* show that port emissions are contributing to poor air quality and higher health risk for people living close to the port area.

* References

- Lau, A. et.al. (2005) "Significant Marine Source for SO_2 Levels in Hong Kong"
- South Coast Air Quality Management District (SCAQMD) (2008) *Multiple Air Toxics Exposure Study in the South Coast Air Basin*.

Background (3/4)

- International trends in emissions control
  - International Maritime Organization (IMO) adopted MARPOL Convention Annex VI in 2005.
    - Hong Kong ratified MARPOL Annex VI in June 2008.
  - In California, OGVs that operate within 24 nautical miles off the California coastline are mandatorily required to switch from burning high sulphur bunker fuel to low sulphur marine fuel starting from July 2009.
  - Effective from 1 January 2010, all ships are required to use fuel with a sulphur content of 0.1% or less while at berth in all European Community ports and within inland waters.

Background (4/4)

- Growing port throughput and marine traffic in the Pearl River Delta region

(TEU throughput in thousands)

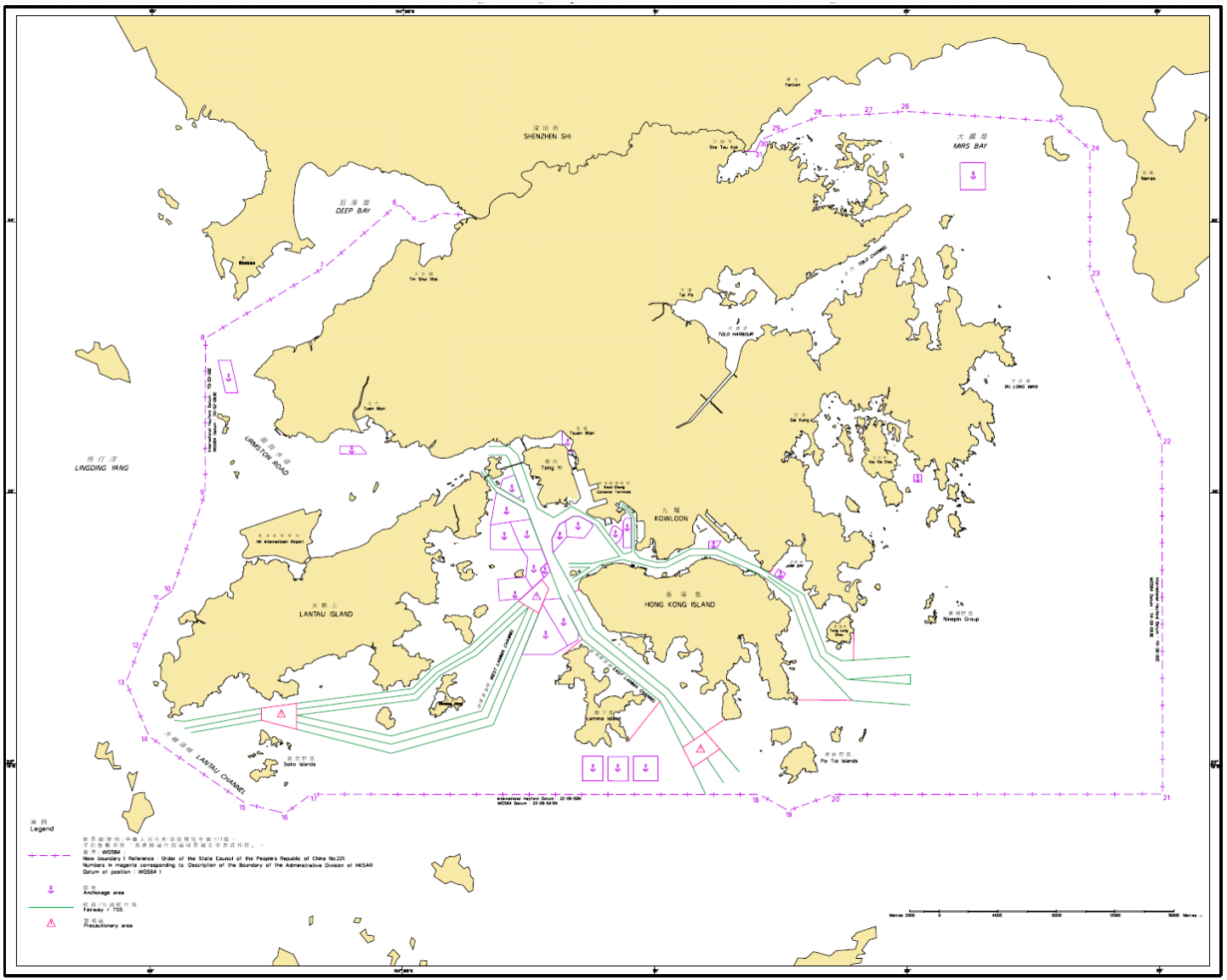
Rank	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	Singapore 15 100	Hong Kong 16 211	Hong Kong 18 098	Hong Kong 17 826	Hong Kong 19 144	Hong Kong 20 499	Hong Kong 21 984	Singapore 23 192	Singapore 24 792	Singapore 27 936	Singapore 29 918	Singapore 25 867
2	Hong Kong 14 582	Singapore 15 945	Singapore 17 087	Singapore 15 571	Singapore 16 941	Singapore 18 411	Singapore 21 329	Hong Kong 22 602	Hong Kong 23 539	Shanghai 26 152	Shanghai 28 006	Shanghai 25 002
3	Kaohsiung 6271	Kaohsiung 6 985	Busan 7 540	Busan 8 073	Busan 9 453	Shanghai 11 280	Shanghai 14 557	Shanghai 18 084	Shanghai 21 710	Hong Kong 23 998	Hong Kong 24 494	Hong Kong 21 040
4	Rotterdam 6011	Busan 6 440	Kaohsiung 7 426	Kaohsiung 7 541	Shanghai 8 610	Shenzhen 10 650	Shenzhen 13 626	Shenzhen 16 197	Shenzhen 18 469	Shenzhen 21 099	Shenzhen 21 417	Shenzhen 18 250
5	Busan 5946	Rotterdam 6 400	Rotterdam 6 275	Shanghai 6 340	Kaohsiung 8 493	Busan 10 408	Busan 11 442	Busan 11 843	Busan 12 039	Busan 13 261	Busan 13 426	Busan 11 980
6	Long Beach 4 098	Long Beach 4 408	Shanghai 5 612	Rotterdam 6 096	Shenzhen 7 614	Kaohsiung 8 843	Kaohsiung 9 714	Kaohsiung 9 471	Kaohsiung 9 775	Rotterdam 10 791	Dubai 11 827	Guangzhou 11 190
7	Hamburg 3 550	Shanghai 4 210	Los Angeles 4 879	Los Angeles 5 184	Rotterdam 6 506	Los Angeles 7 179	Rotterdam 8 281	Rotterdam 9 287	Rotterdam 9 600	Dubai 10 653	Guangzhou 11 001	Dubai 11 120
8	Los Angeles 3 378	Los Angeles 3829	Long Beach 4 601	Shenzhen 5 043	Los Angeles 6 106	Rotterdam 7 107	Los Angeles 7 321	Hamburg 8 088	Hamburg 8 862	Kaohsiung 10 257	Ningbo-Zhoushan 10 846	Ningbo-Zhoushan 10 503
9	Antwerp 3 266	Hamburg 3 750	Hamburg 4 248	Hamburg 4 689	Hamburg 5 374	Hamburg 6 138	Hamburg 7 003	Dubai 7 619	Dubai 8 783	Hamburg 9 890	Rotterdam 10 784	Qingdao 10 260
10	Shanghai 3 066	Antwerp 3614	Antwerp 4 082	Long Beach 4 463	Antwerp 4 777	Dubai 5 445	Dubai 6 429	Los Angeles 7 485	Los Angeles 8 470	Qingdao 9 466	Qingdao 10 377	Rotterdam 9 743

Objective and Scope of Study (1/4)

- Objectives of the Study:
  - To produce an emission inventory of ocean-going vessels (OGVs) and river vessels (RVs) for 2007, the base year, within Hong Kong waters;
  - To back calculate an emission inventory of OGVs and RVs for the years 1990 to 2006; and
  - To project an emission inventory of OGVs and RVs from 2008 to 2020.

Objective and Scope of Study (2/4)

Boundary of Hong Kong Waters



Source: HK Marine Department

Objective and Scope of Study (3/4)

- OGVs and RVs
  - Classified by specific function of vessels
    - Chemical Carrier/Tanker;
    - Conventional Cargo Vessel;
    - Cruise/Ferry;
    - Dry Bulk Carrier;
    - Fishing/Fish Processing Vessel;
    - Fully Cellular Container Vessel (FCCV);
    - Gas Carrier/Tanker;
    - Lighter/Barge/Cargo Junk;
    - Oil Tanker;
    - Pleasure Vessel;
    - Roll On/Roll Off;
    - Semi-container Vessel;
    - Tug; and
    - Others

Objective and Scope of Study (4/4)

- Air pollutants to be included in the inventory:
  - Sulphur dioxide (SO_2)
  - Nitrogen oxides (NO_x)
  - Particulate Matter (PM_{10} and $PM_{2.5}$)
  - Volatile Organic Compound (VOC)
  - Carbon Monoxide (CO)

- Emission sources:
  - Main engine (ME)
  - Auxiliary engine (AE)
  - Auxiliary boiler (AB)

Methodology (1/2)

- Activity-based approach
  - Power rating information
    - Main engine, auxiliary engine, auxiliary boiler
  - Time in mode
    - Cruise, fairway cruise, slow cruise, maneuvering, hotelling
  - Engine activity (load factor)
  - Fractional load emission factors in g/kWh

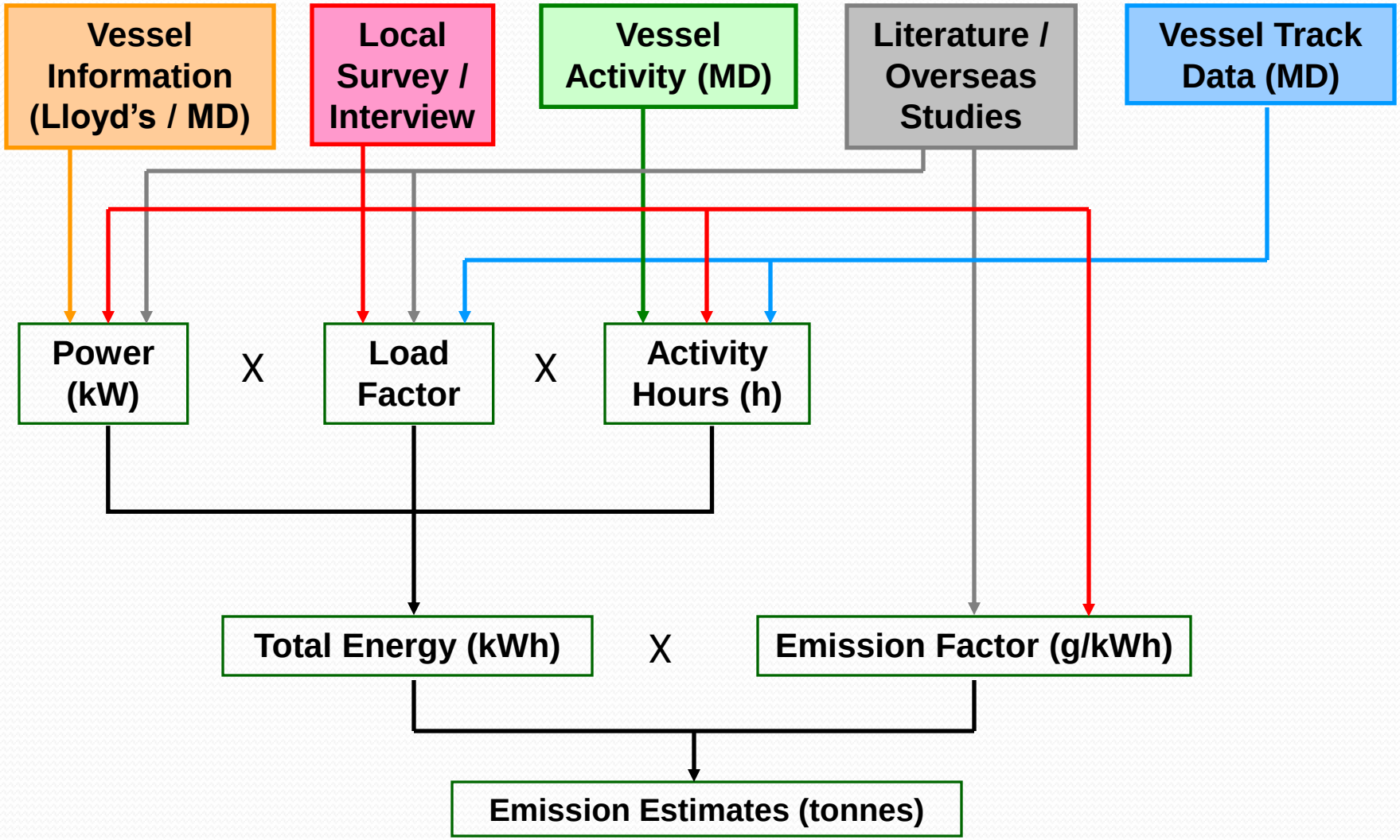
$$\textbf{Total Emission}_{\text{(pollutant, ship type)}} = \sum \textbf{Emission}_{\text{(pollutant, ship type, mode)}}$$

$$\textbf{Emission}_{\text{(pollutant, ship type, mode)}} = \textbf{P} \times \textbf{LF} \times \textbf{TIM} \times \textbf{EF}$$

where P: vessel engine power in kWh
LF: load factor (or fractional load) of engine
TIM: operational time in mode
EF: emission factor based on engine and fuel type in g/kWh

Methodology (2/2)

- Emissions estimation flow chart



Data Collection (1/11)

- Vessel arrival data
- Transit vessel data
- Vessel activity data

Published information

First-hand information

- Main/auxiliary engine and boiler particulars
- Engine/boiler activities
- Operation characteristics
- Fuel type and fuel use information

- Vessel information
- Vessel tracking data

Additional information

Data Collection (2/11)

- Lloyd's Data
- MD's published data and data archive
- Local surveys and interviews
- Overseas studies
  - ICF (2009) *Current Methodologies in Preparing Mobile Source Port-related Emission Inventories*, Final Report, April 2009.
  - Starcrest Consulting Group (2010) *Port of Los Angeles (POLA) Inventory of Air Emissions 2009*, December 2010.
- MD's vessel track data

Data Collection (3/11)

- Local surveys:
  - 273 returns from OGVs and RVs
  - Other survey forms completed for major Macau ferry routes and river trade services
  - Provide useful information on vessel operation and fuel quality
- Interviews:
  - Personal interviews with members of the maritime industry
  - Supplementary information

Data Collection (4/11)

1 Vessel Information

Vessel Name: _____		**IMO Number:** _____	☐ **Ocean-going Vessel** ☐ **River Vessel**
Ship Owner: _____		**Operating Agent:** _____	
Vessel Type: ☐**A**. Chemical Carrier/Tanker;	☐**B**. Conventional Cargo Vessel;	☐**C**. Cruise/Ferry;	☐**D**. Dry Bulk Carrier;
☐**E**. Fishing/Fish Processing Vessel;	☐**F**. Fully Cellular Container Vessel;	☐**G**. Gas Carrier/Tanker;	☐**H**. Lighter/Barge/Cargo Junk;
☐**I**. Oil Tanker;	☐**J**. Pleasure Vessel;	☐**K**. Roll On/Roll Off;	☐**L**. Semi-container Vessel;
☐**M**. Tug;	☐**N**. Others (please fill in) _____		
Maximum Vessel Speed:____ ☐knot(nm/h) ☐km/h	**Vessel LOA:** _____ meters	**DWT:** _____ Metric tons	**Gross Tonnage :** _____

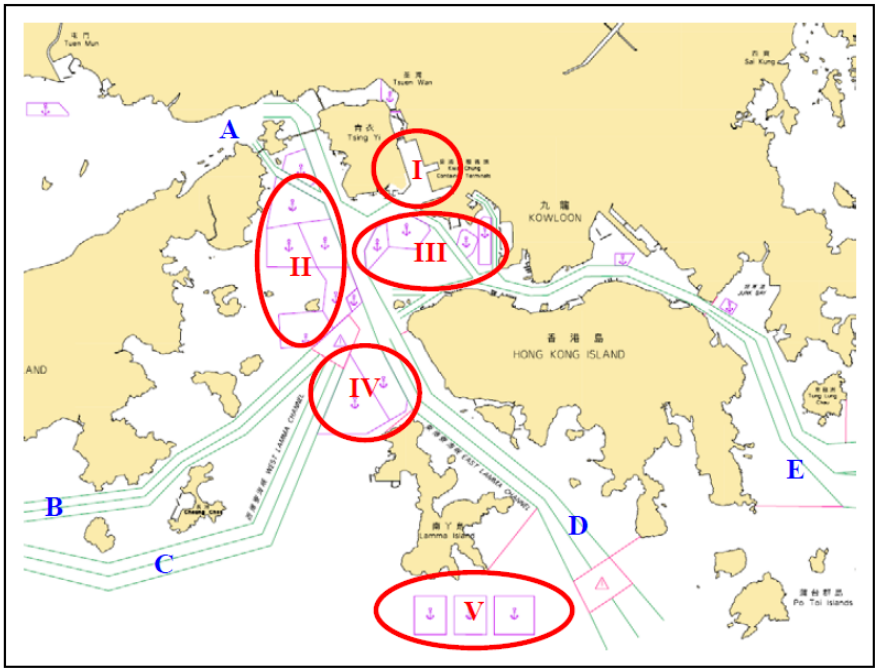
2 Call Information

Arrival: ____/____/ 2009 (dd/mm/yyyy)
Departure: ____/____/ 2009 (dd/mm/yyyy)

Last Port: _____ **Next Port:** _____

Berthing Locations: (you may tick more than one)
☐I ☐II ☐III ☐IV ☐V ☐Tuen Mun River Trade Terminal
☐PCWA: (please fill in)_____
☐Others: (please fill in)_____

Routing:
You enter Hong Kong waters through: ☐A ☐B ☐C ☐D ☐E
You depart Hong Kong waters through: ☐A ☐B ☐C ☐D ☐E



Berthing Site:
- **I**: Kwai Chung Terminals
- **II**: Western Anchorage
- **III**: Western Dangerous Anchorage and Yau Ma Tei Anchorage
- **IV**: North Lamma Anchorage
- **V**: South Lamma Anchorage

Shipping Route:
- **A**: Ma Wan Fairway
- **B**: Adamasta Chanel
- **C**: West Lamma Channel
- **D**: East Lamma Channel
- **E**: Tathong Channel

Data Collection (5/11)

3 Engine Information

3.1 Main (Propulsion) Engine (For diesel-electric/ generator-set engine on cruise ships, please list them under "3.2 Auxiliary engine/generator" on Page 3)

Number of Main Engines: ____	**Engine Type:** ☐Gas turbine ☐Steam turbine ☐2-Stroke diesel engine ☐4-Stroke diesel engine	
Total MCR Power: ____ ☐kW ☐hp	**RPM at MCR:** ____	**Engine Speed Type:** ☐High ☐Medium ☐Slow
Fuel Used #1: ☐HFO ☐MDO ☐MGO, S% ____		**Fuel Used #2:** ☐HFO ☐MDO ☐MGO, S% ____
Average Fuel Consumption per Hour: 1) Average outside HK waters (within 100 nautical miles from HK coastline): ____ ☐kg ☐liter 2) Average within HK waters ____ ☐kg ☐liter		
Main Engine Operating Hours (from entering to leaving Hong Kong waters) : **1) Underway outside** Hong Kong waters (within 100 nautical miles from HK coastline) ____hours; **2) Underway within** Hong Kong waters ____ hours; **3) Maneuvering*** ____ hours; **4) Loading/Unloading** ____ hours; **5) Berthing**** ____ hours		
Operating Power and Vessel Speed: Power used when **underway outside** Hong Kong waters: ____ ☐kW ☐hp, **Vessel Speed:** ____ knot Power used when **underway within** Hong Kong waters: ____ ☐kW ☐hp, **Vessel Speed:** ____ knot Power used when **maneuvering*** within Hong Kong waters: ____ ☐kW ☐hp, **Vessel Speed:** ____ knot Power used when **loading/unloading** within Hong Kong waters: ____ ☐kW ☐hp, **Vessel Speed:** 0 knot Power used when **berthing**** within Hong Kong waters: ____ ☐kW ☐hp, **Vessel Speed:** 0 knot		
Do you switch fuel in your main engine(s)? **Outside Hong Kong Waters:** ☐Yes ☐No; If Yes, please continue **(i) From** ☐HFO ☐MDO ☐MGO **To** ☐HFO ☐MDO ☐MGO; **S% from** ____ **To** ____ **(ii) Time** ____hours before entering and ____ hours after leaving HK Waters		**Within Hong Kong Waters:** ☐Yes ☐No; If Yes, please continue **(i) From** ☐HFO ☐MDO ☐MGO **To** ☐HFO ☐MDO ☐MGO; **S% from** ____ **To** ____ **(ii) During** ☐Underway ☐Maneuvering* ☐Loading/Unloading ☐Berthing**

* Maneuvering is when vessel moves at very slow speed executing a turn or other maneuver just before/after mooring at buoy/anchorage or berthing.
Berthing mode **does not include loading/unloading.

Data Collection (6/11)

3.2 Auxiliary Engine/Generator and all Diesel-Electric Engines (excluding emergency and standby engines)

Engine	Engine #1	Engine #2	Engine #3	Engine #4	Engine #5	Engine #6
MCR Power	☐kW ☐hp	☐kW ☐hp	☐kW ☐hp	☐kW ☐hp	☐kW ☐hp	☐kW ☐hp
Engine Type	☐Gas Turbine ☐Diesel Engine ☐2-Stroke ☐4-Stroke	☐Gas Turbine ☐Diesel Engine ☐2-Stroke ☐4-Stroke	☐Gas Turbine ☐Diesel Engine ☐2-Stroke ☐4-Stroke	☐Gas Turbine ☐Diesel Engine ☐2-Stroke ☐4-Stroke	☐Gas Turbine ☐Diesel Engine ☐2-Stroke ☐4-Stroke	☐Gas Turbine ☐Diesel Engine ☐2-Stroke ☐4-Stroke
Fuel Type used within Hong Kong Waters	☐HFO: S%____ ☐MDO: S%____ ☐MGO: S%____	☐HFO: S%____ ☐MDO: S%____ ☐MGO: S%____	☐HFO: S%____ ☐MDO: S%____ ☐MGO: S%____	☐HFO: S%____ ☐MDO: S%____ ☐MGO: S%____	☐HFO: S%____ ☐MDO: S%____ ☐MGO: S%____	☐HFO: S%____ ☐MDO: S%____ ☐MGO: S%____
Average Fuel Consumption per hour	☐kg ☐liter	☐kg ☐liter	☐kg ☐liter	☐kg ☐liter	☐kg ☐liter	☐kg ☐liter
Auxiliary engine operating hours:						
1) Underway						
outside HK waters	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No
within HK waters	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No
2) Maneuvering*	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No
3) Loading/Unloading	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No
4) Berthing**	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No	☐Yes___hrs ☐No

Combined power generated from the above auxiliary engine(s) when:

1) Underway: _____ ☐kW ☐hp; **2) Maneuvering*** _____ ☐kW ☐hp; **3) Loading/Unloading** _____ ☐kW ☐hp; **4) Berthing**** _____ ☐kW ☐hp

Do you switch fuel in your auxiliary engine(s)?

Outside Hong Kong Waters: ☐Yes ☐No; If Yes, please continue

(i) From ☐HFO ☐MDO ☐MGO **To** ☐HFO ☐MDO ☐MGO;

(ii)Time _____ hours before entering and _____ hours after leaving HK Waters

Within Hong Kong Waters: ☐Yes ☐No; If Yes, please continue

(i) From ☐HFO ☐MDO ☐MGO **To** ☐HFO ☐MDO ☐MGO;

(ii) During ☐Underway ☐Maneuvering* ☐Loading/Unloading ☐Berthing**

Data Collection (7/11)

3.3 Onboard Boiler (excluding standby boilers)

Boiler	Boiler #1	Boiler #2	Boiler #3	Boiler #4
Capacity	_____ ton Steam/hour	_____ ton Steam/hour	_____ ton Steam/hour	_____ ton Steam/hour
Purpose	☐Providing hot water ☐Heating residual oil ☐Producing steam for pumps ☐Others: _____	☐Providing hot water ☐Heating residual oil ☐Producing steam for pumps ☐Others: _____	☐Providing hot water ☐Heating residual oil ☐Producing steam for pumps ☐Others: _____	☐Providing hot water ☐Heating residual oil ☐Producing steam for pumps ☐Others: _____
Fuel Type used within Hong Kong Waters	☐HFO: S%_____ ☐MDO: S%_____ ☐MGO: S%_____	☐HFO: S%_____ ☐MDO: S%_____ ☐MGO: S%_____	☐HFO: S%_____ ☐MDO: S%_____ ☐MGO: S%_____	☐HFO: S%_____ ☐MDO: S%_____ ☐MGO: S%_____
Average Fuel Consumption per Hour	_____ ☐kg/hour ☐liter/hour	_____ ☐kg/hour ☐liter/hour	_____ ☐kg/hour ☐liter/hour	_____ ☐kg/hour ☐liter/hour
Boiler Operating Hours				
1) Underway outside HK	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours
2) Underway within HK	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours
3) Maneuvering*	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours
4) Loading/Unloading	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours
5) Berthing**	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours	Duration: _____ hours

Do you switch fuel in your boiler(s)

Outside Hong Kong Waters: ☐Yes ☐No; If Yes, please continue
(i) From ☐HFO ☐MDO ☐MGO **To** ☐HFO ☐MDO ☐MGO;
(ii)Time _____ hours before entering and _____ hours after leaving HK Waters

Within Hong Kong Waters: ☐Yes ☐No; If Yes, please continue
(i) From ☐HFO ☐MDO ☐MGO **To** ☐HFO ☐MDO ☐MGO;
(ii) During ☐Underway ☐Maneuvering* ☐Loading/Unloading ☐Berthing**

^ Is your vessel a regular visitor to the port of Hong Kong? ☐Yes ☐No; If Yes, **how often?** _____ calls in 2008

 # Survey form completed by: **Name:** _____ **Date:** _____/_____/ 09 (dd/mm) **Email address:** _____

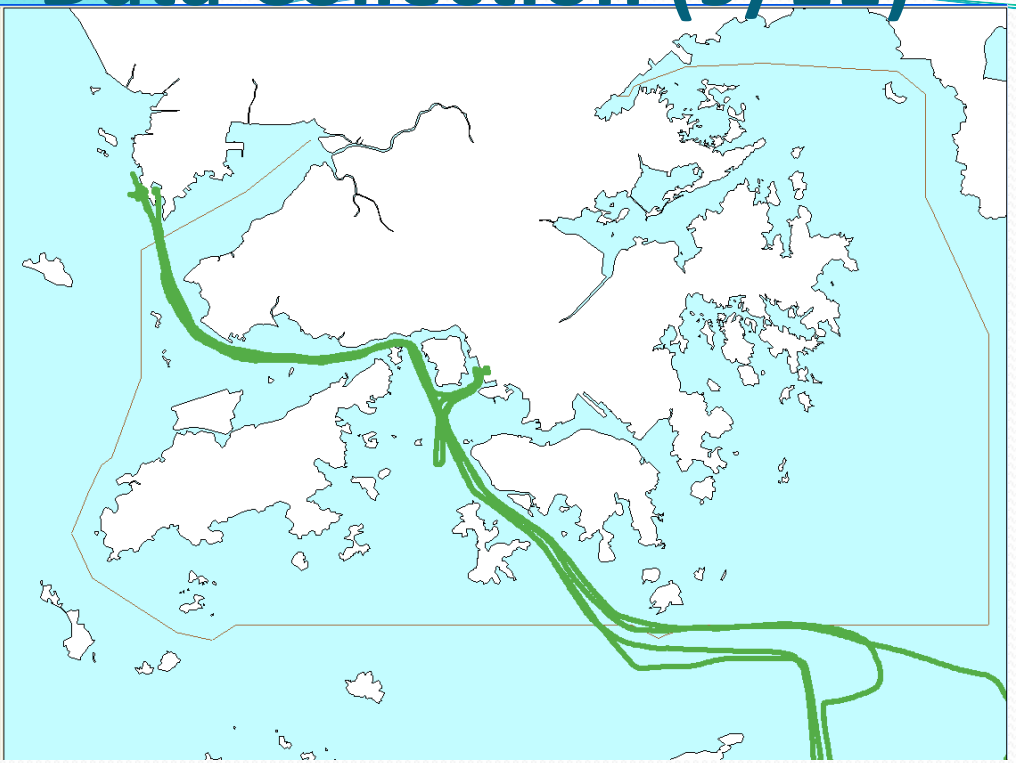
- End of Survey. Thank You -

Data Collection (8/11)

- Vessel Track Data:
  - Two-week vessel track data of 2007 was used to supplement and verify data collected from other sources:
    - Vessel track / position
    - Call duration
    - Vessel speed profile
    - Time in mode (TIM) characterization
    - Main Engine Load factor estimation (by Propeller Law)

$$\textit{Load Factor} = (\textit{Actual Speed}/\textit{Maximum Speed})^3$$

Data Collection (9/11)



Vessel Track and Speed Profile

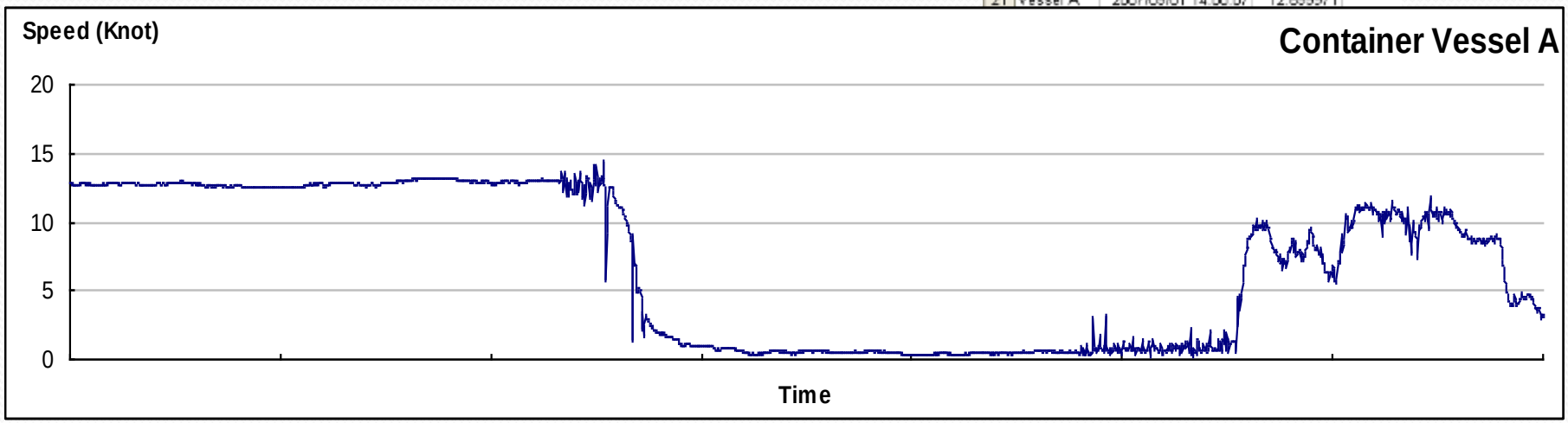
Microsoft Excel - Book1

File Edit View Insert Format Tools Data Window

Arial 10 B I U

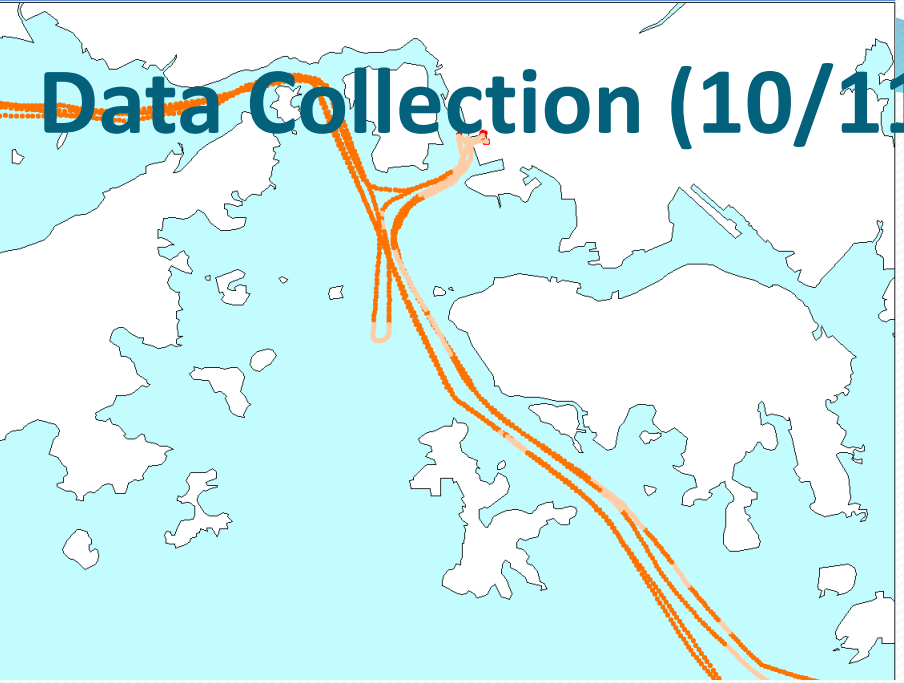
Q5

	A	B	C	D
1	Vessel A	2007/09/01 13:50:03	12.699964	
2	Vessel A	2007/09/01 13:50:33	12.699946	
3	Vessel A	2007/09/01 13:51:03	12.799951	
4	Vessel A	2007/09/01 13:51:33	12.699965	
5	Vessel A	2007/09/01 13:52:03	12.699955	
6	Vessel A	2007/09/01 13:52:33	12.999935	
7	Vessel A	2007/09/01 13:53:04	12.999963	
8	Vessel A	2007/09/01 13:53:34	12.999953	
9	Vessel A	2007/09/01 13:54:06	12.699967	
10	Vessel A	2007/09/01 13:54:37	12.999969	
11	Vessel A	2007/09/01 13:55:07	12.999986	
12	Vessel A	2007/09/01 13:56:37	12.999935	
13	Vessel A	2007/09/01 13:56:07	12.69964	
14	Vessel A	2007/09/01 13:56:37	12.699934	
15	Vessel A	2007/09/01 13:57:07	12.699956	
16	Vessel A	2007/09/01 13:57:37	12.699953	
17	Vessel A	2007/09/01 13:58:07	12.699973	
18	Vessel A	2007/09/01 13:58:37	12.699965	
19	Vessel A	2007/09/01 13:59:07	12.699977	
20	Vessel A	2007/09/01 13:59:37	12.699941	
21	Vessel A	2007/09/01 14:00:07	12.699971	

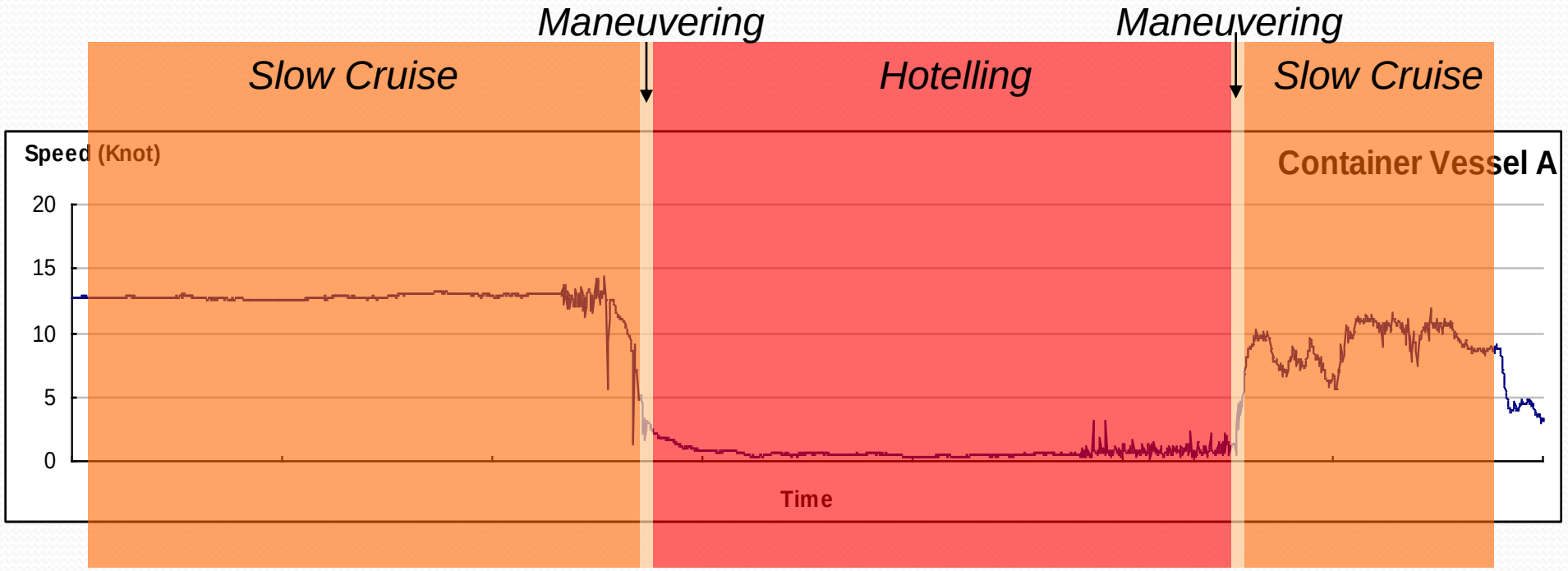


Source: HK Marine Department

Data Collection (10/11)

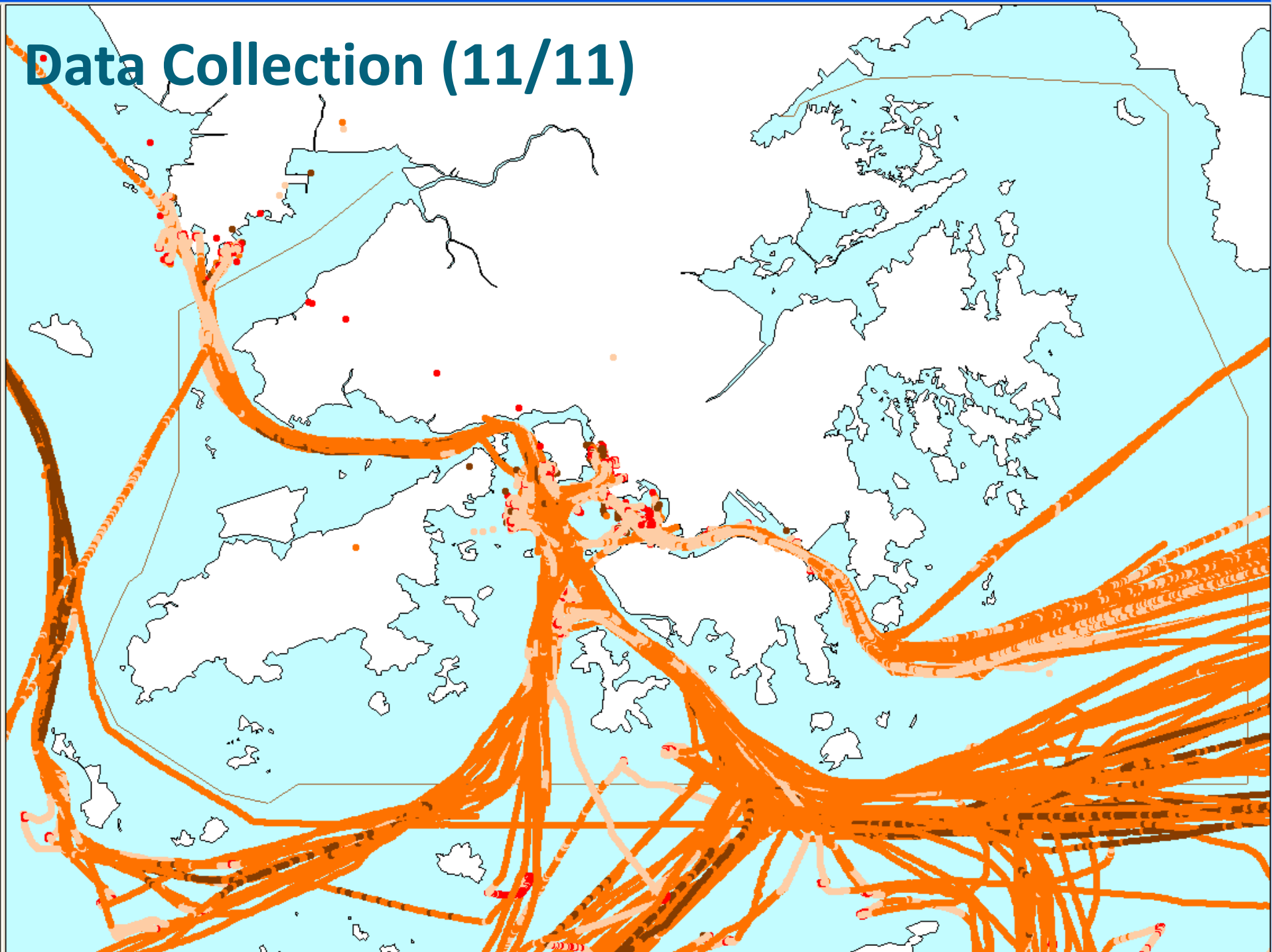


Time-in-mode Characterization



Source: Marine Department

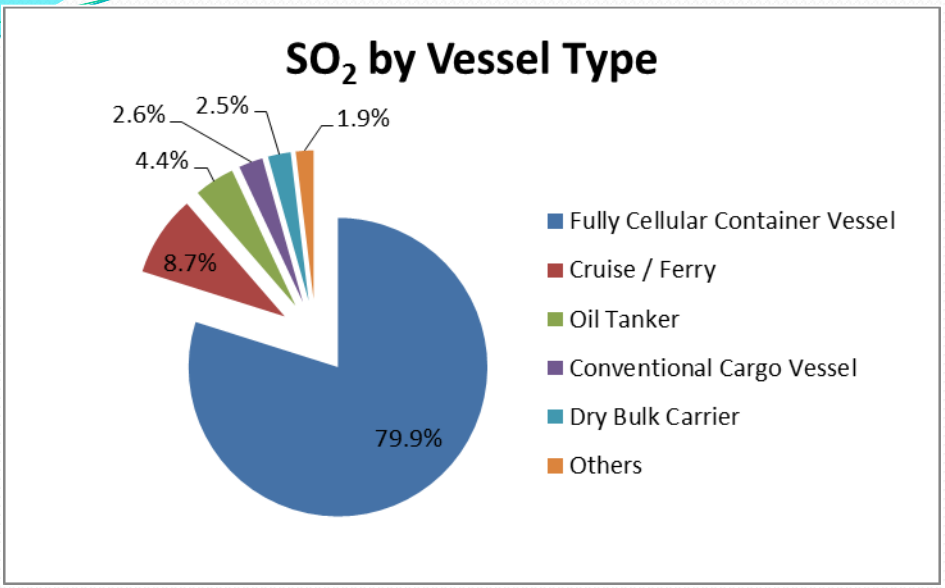
Data Collection (11/11)

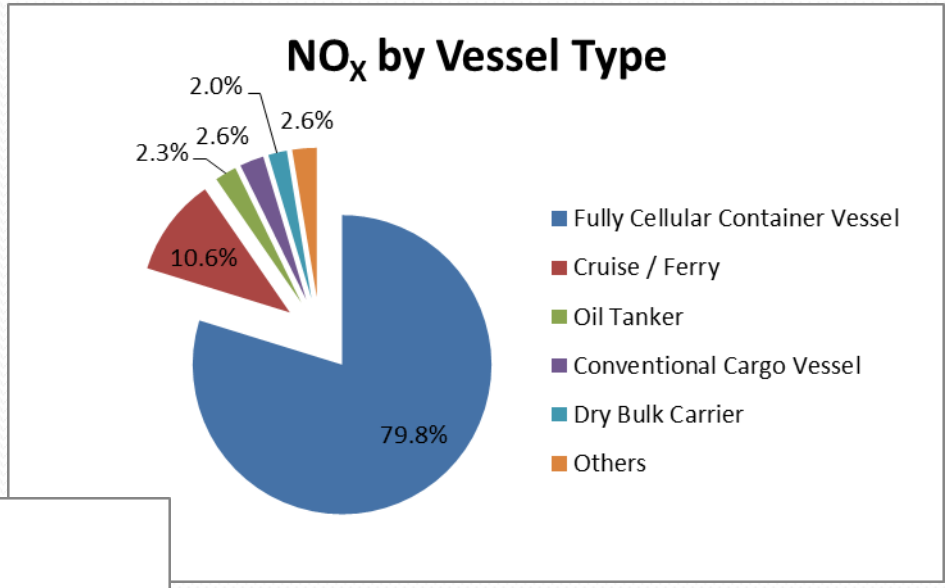


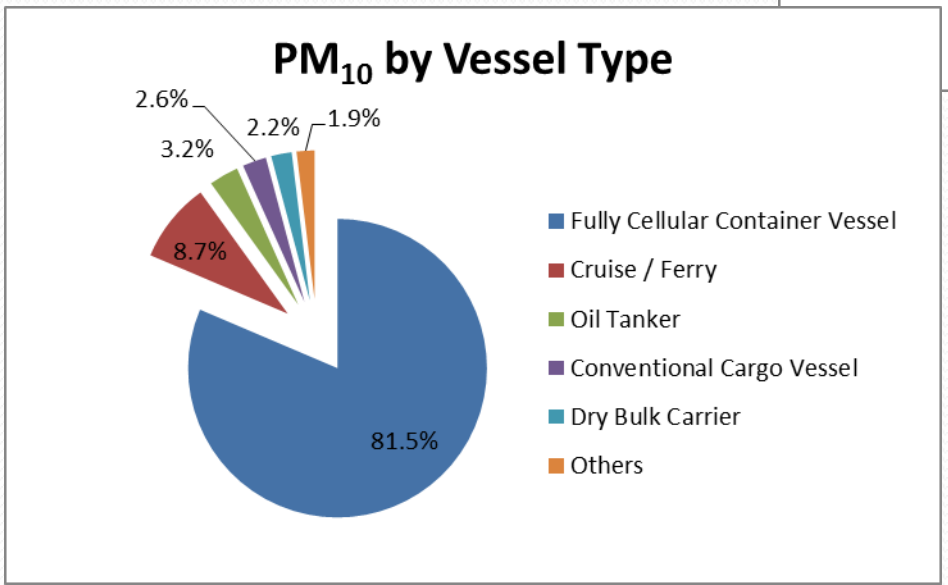
Base Year Emission Inventory 2007 (1/10)

- Key parameters for OGVs:
  - **Fuel type:** OGVs with ME < 1,100 kW use distillate fuel and have no boiler
  - **Effective fuel sulphur contents:** based on local survey findings
    - HFO (2.83% for ME; 2.64% for AE; 2.77% for AB)
    - Distillate – MDO/MGO (0.5%)
  - **ME power** (kW)
  - **AE power** (kW)
  - **Boiler energy defaults** (kW)
  - **Time-in-mode**
  - **Load factors for ME and AE**
  - **Emission factors**

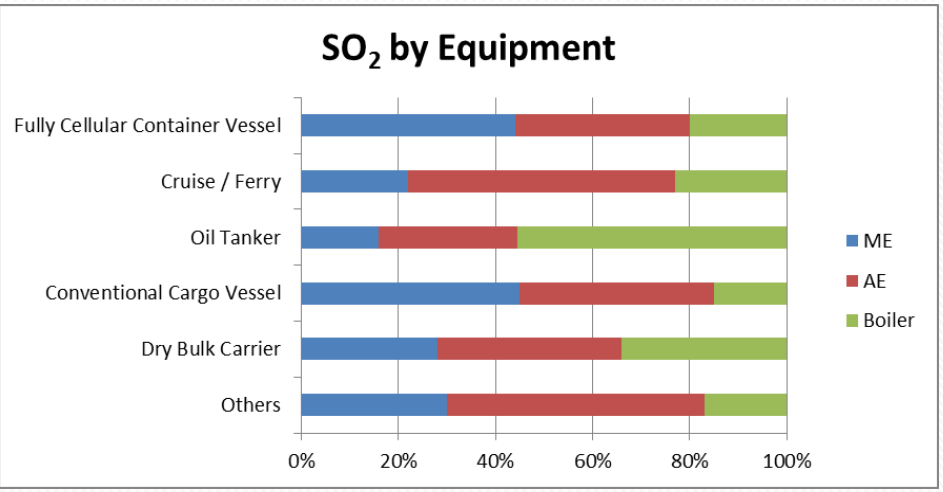
Base Year Emission Inventory 2007 (2/10)

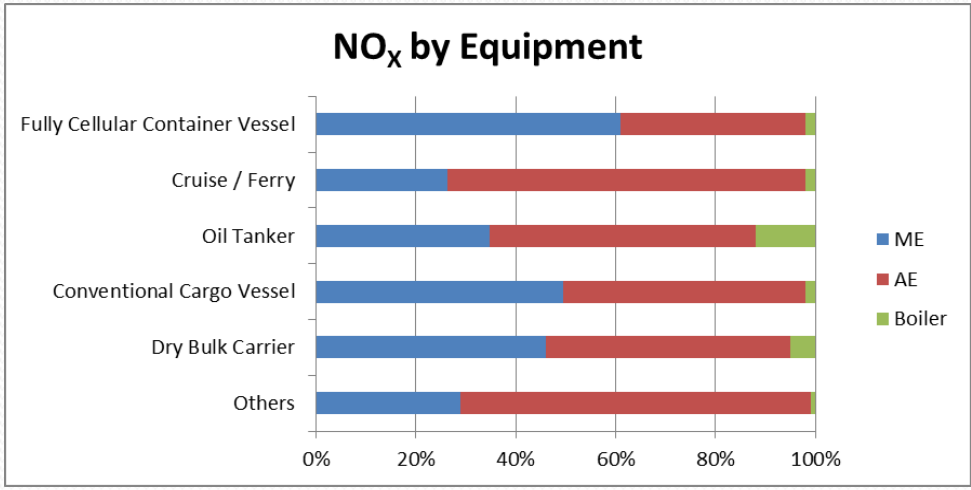


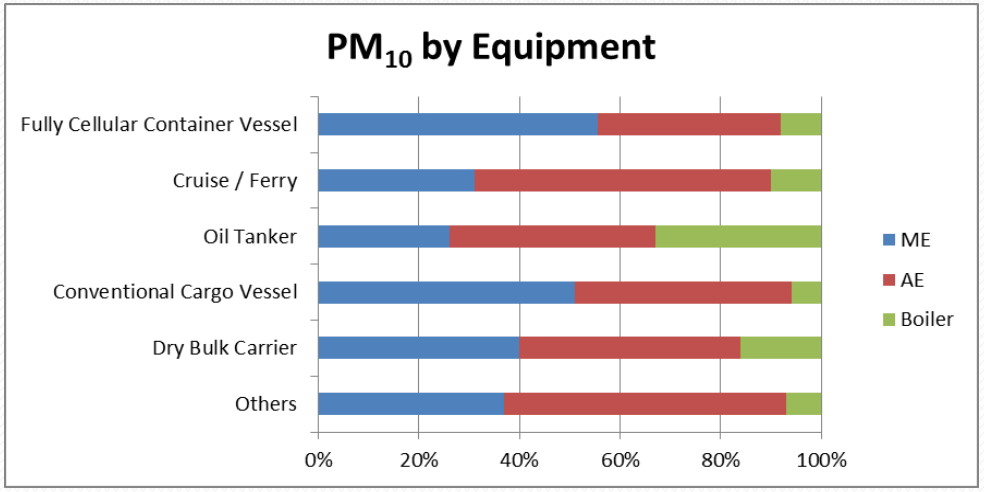




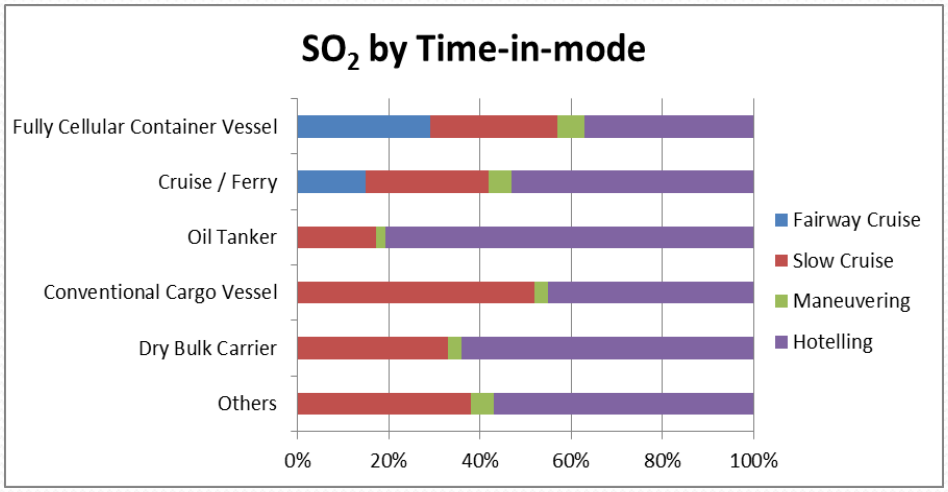
Base Year Emission Inventory 2007 (3/10)

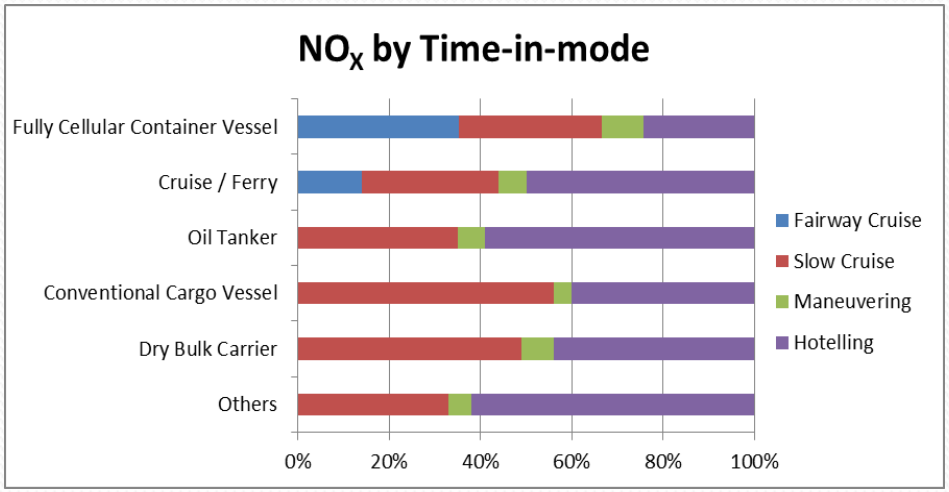


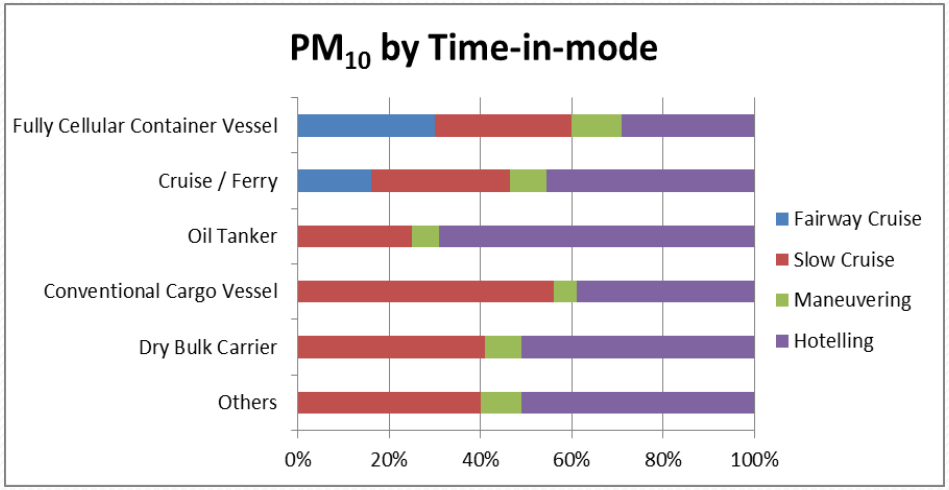




Base Year Emission Inventory 2007 (4/10)



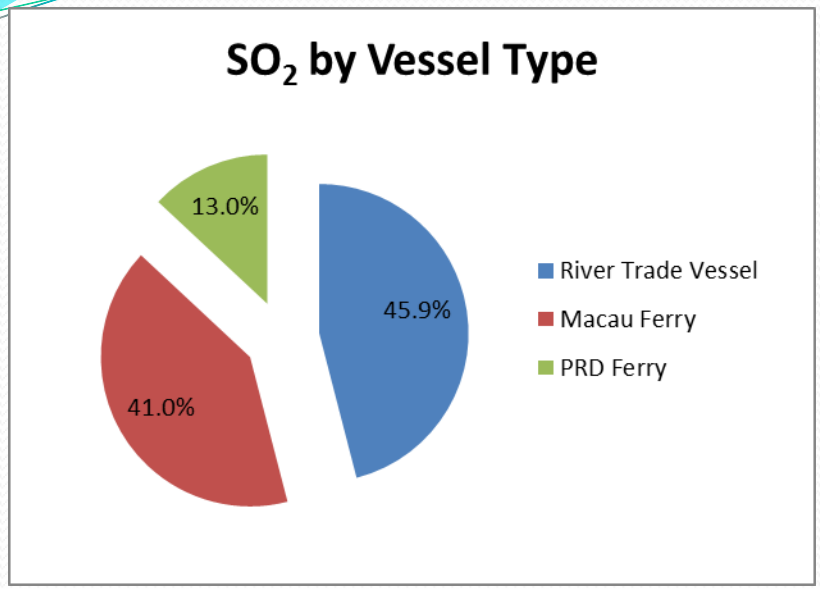


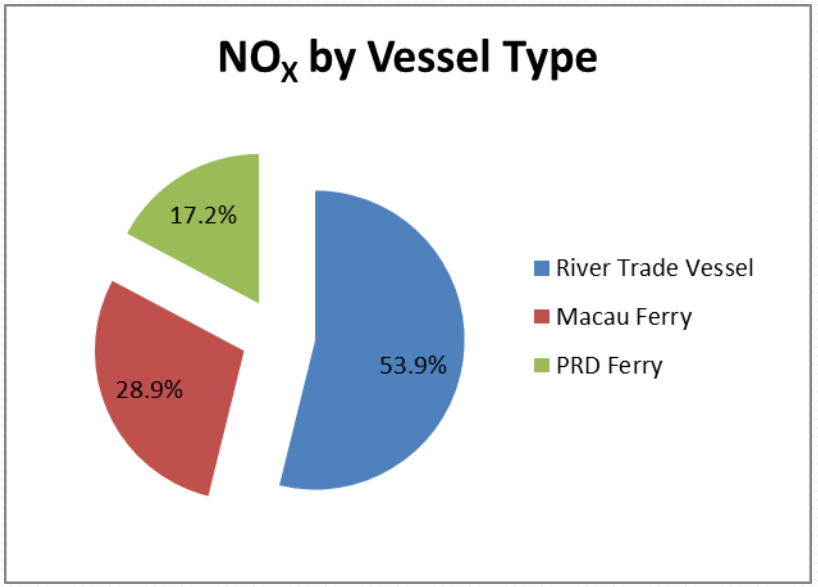


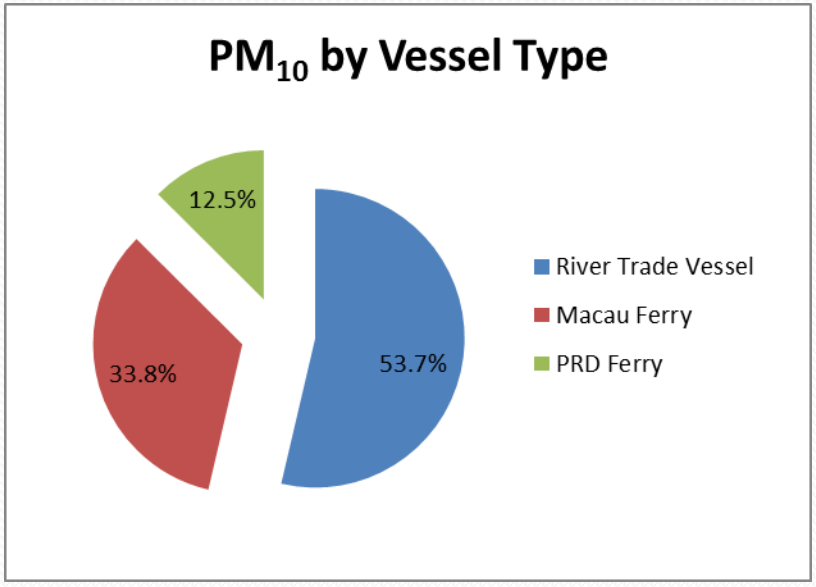
Base Year Emission Inventory 2007 (5/10)

- Key parameters for RVs:
  - **Fuel type:** RVs use distillate fuel and have no boiler
  - **Effective fuel sulphur contents:** based on local survey findings
    - Distillate – MDO/MGO (0.5%)
  - **ME power (kW)**
  - **AE power (kW)**
  - **Time-in-mode**
  - **Load factors for ME and AE**
  - **Emission factors**

Base Year Emission Inventory 2007 (6/10)

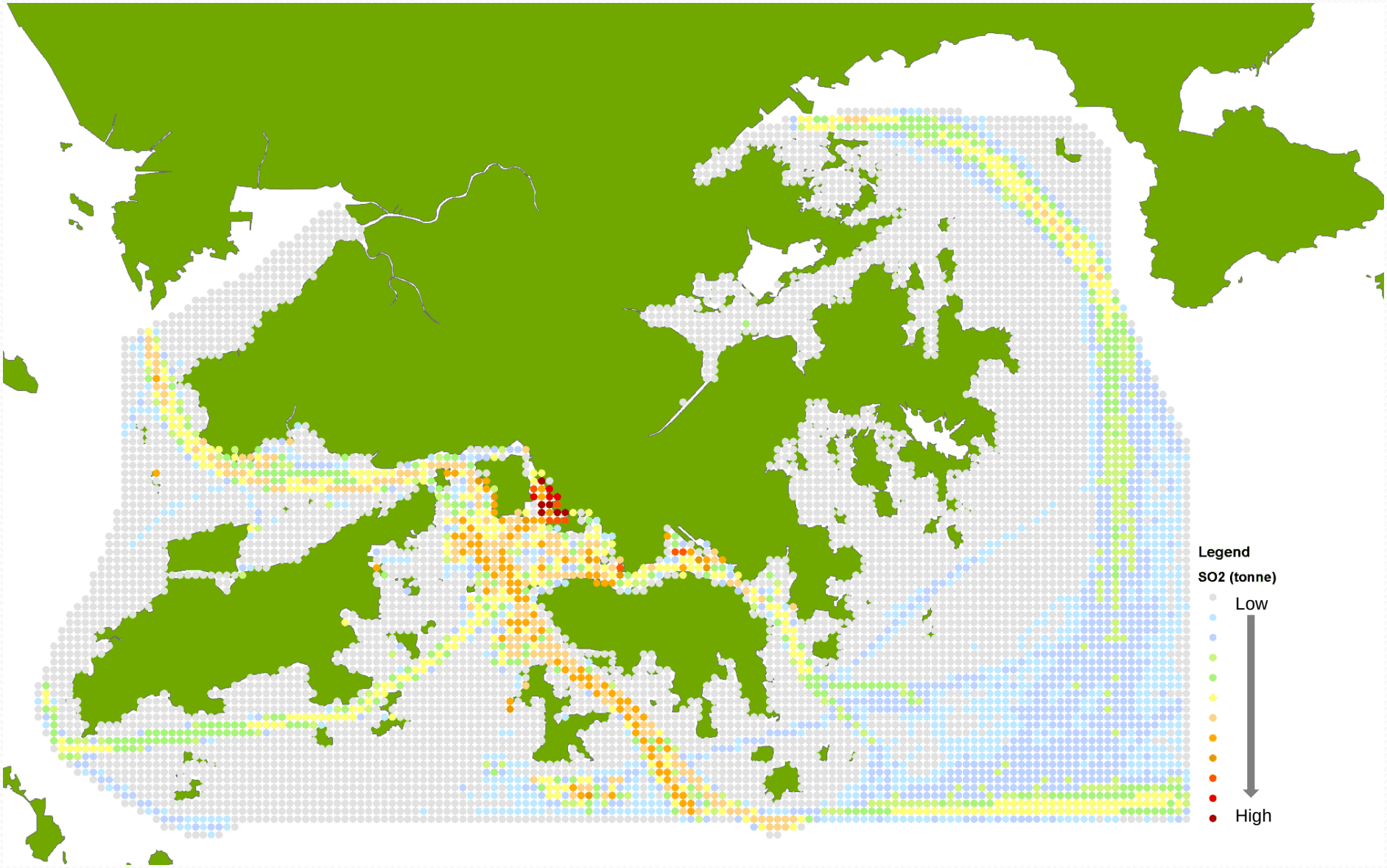






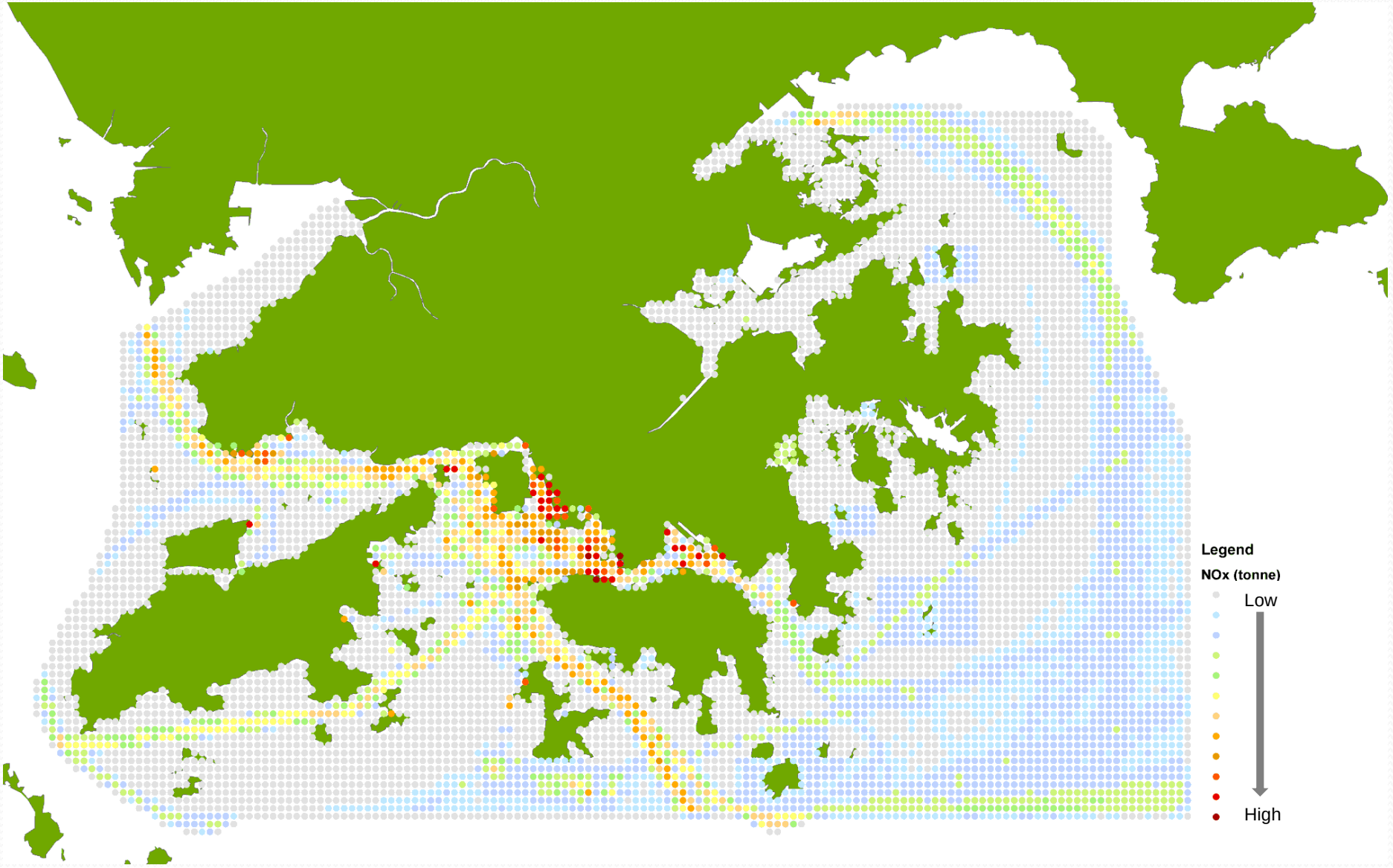
Base Year Emission Inventory 2007 (7/10)

Spatial Distribution of SO_2 Emission by 500 x 500m Grid



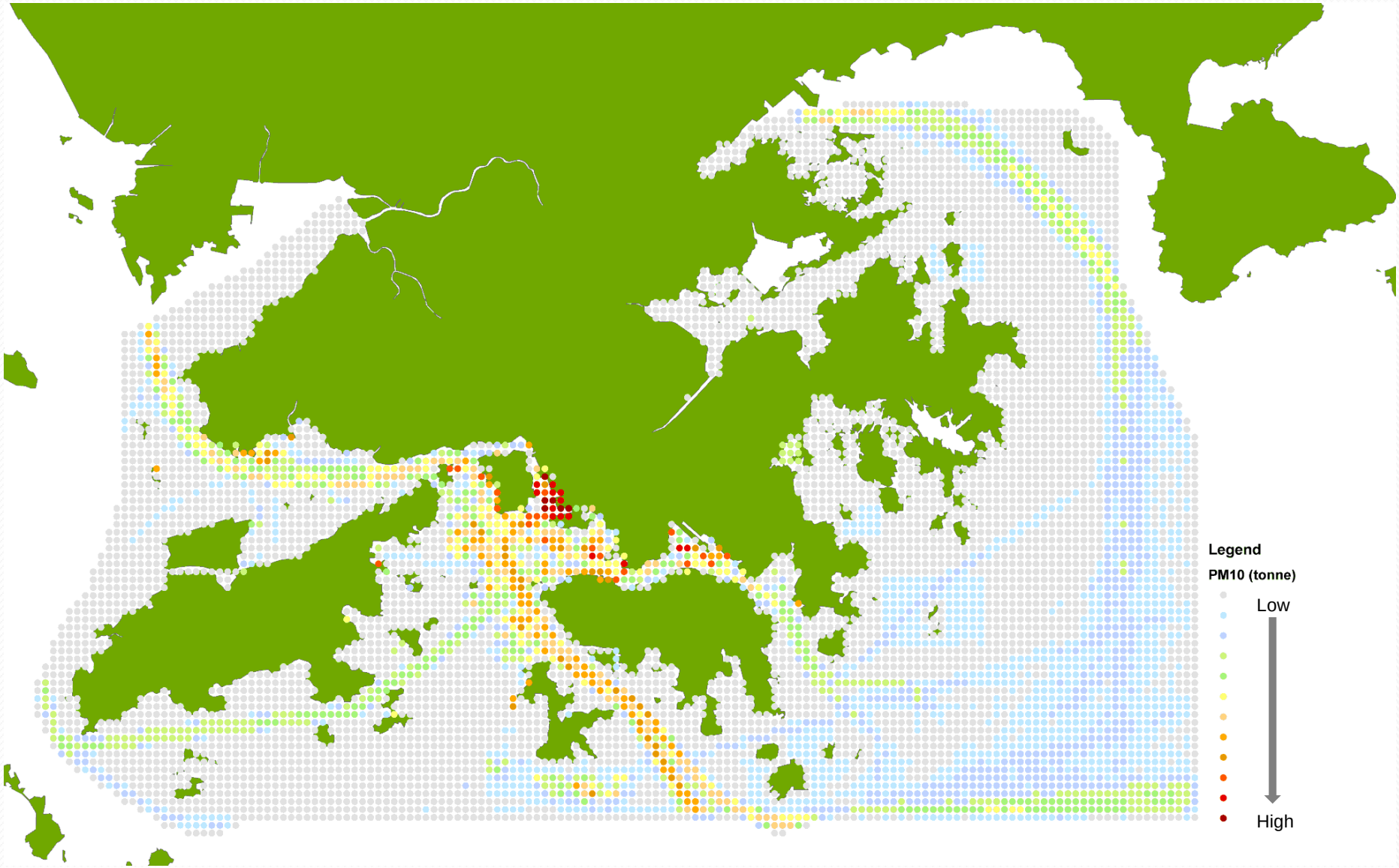
Base Year Emission Inventory 2007 (8/10)

Spatial Distribution of NO_X Emission by 500 x 500m Grid



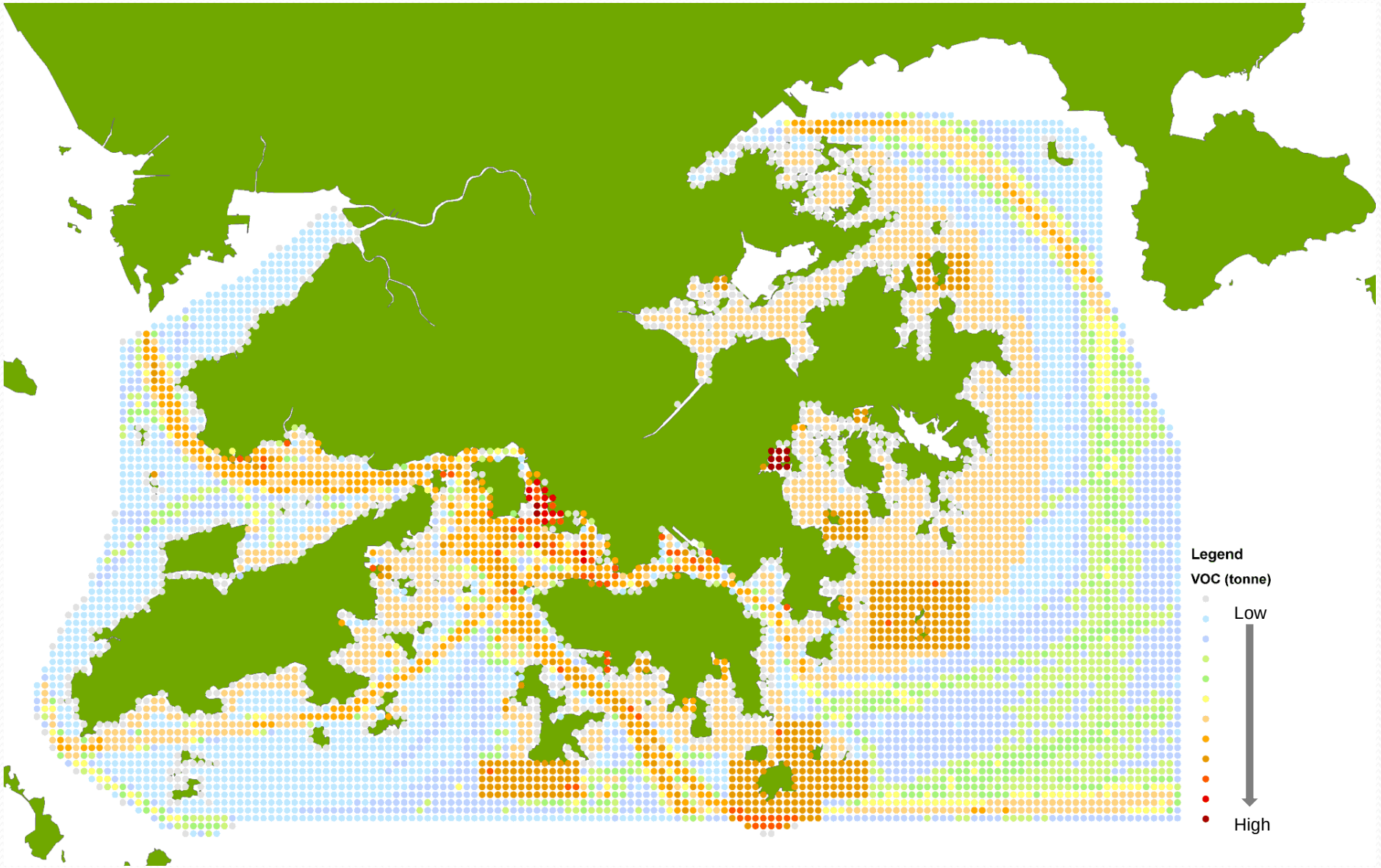
Base Year Emission Inventory 2007 (9/10)

Spatial Distribution of PM_{10} Emission by 500 x 500m Grid



Base Year Emission Inventory 2007 (10/10)

Spatial Distribution of VOC Emission by 500 x 500m Grid



Historical Emission Inventory 1990-2006 (1/2)

OGVs

- Estimated by vessel type and air pollutant, based on the 2007 inventory
- The following factors were considered:
  - Trends in vessel activity
    - Vessel arrival number by vessel type
    - Time-in-mode by vessel type
  - Trends in vessel size and power ratings
    - GRT, ME and AE power rating, energy default of AB
  - Trends in fuel use
    - Fuel type, fuel sulphur content
  - Load factors
  - Changes in emission factors
    - Due to fuel change, fuel sulphur content change, emission reduction technology under IMO requirements

Historical Emission Inventory 1990-2006 (2/2)

RVs

- Estimated by vessel type and air pollutant, based on the 2007 inventory
- The following factors were considered:
  - Trends in vessel activity
    - Vessel arrival number by vessel type
    - Time-in-mode by vessel type
  - Trends in vessel size and power ratings
    - GRT, ME and AE power rating
- Other factors remained constant

Projected Emission Inventory 2008-2020 (1/2)

OGVs

- Estimated by vessel type and air pollutant, based on the 2007 inventory and 2008-2010 published data
- The following factors were considered to project for 2011-2020:
  - Trends in vessel activity
    - Vessel arrival number by vessel type
    - Time-in-mode by vessel type
  - Trends in vessel size and power ratings
    - Splits of deadweight tonnage or passenger carrying capacity classes
  - Trends in fuel use
    - Fuel sulphur content
  - Development of emission reduction technology

Projected Emission Inventory 2008-2020 (2/2)

RVs

- Estimated by vessel type and air pollutant, based on the 2007 inventory and 2008-2010 published data
- The following factors were considered to project for 2011-2020:
  - Trends in vessel activity
    - Vessel arrival number by vessel type
    - Time-in-mode by vessel type
- Other factors remained constant

Discussion and Conclusion (1/3)

- Improvements to Past Inventories
  - Better understanding of **marine fuel** used by vessels through local surveys and interviews
  - **Boiler emission** was included for OGVs in the new estimation
  - Improvement in **time-in-mode estimation**, by tapping further into Marine Department's database:
    - Vessel Activity Reports (VARs) to determine hotelling time
    - Vessel track data to determine fairway cruise / slow cruise / maneuvering time and main engine load factor
  - Improvement of **main engine power data** from Lloyd's Data (OGVs) or MD's archive (RVs)
    - Corinair's GRT correlated engine power was used in the past

Discussion and Conclusion (2/3)

- Significance of the Study
  - Add **new temporal and spatial dimensions** to the marine vessels emission inventory
  - With LVs and transit vessels emission, **a full picture of marine vessel emissions** in Hong Kong can be provided
  - **Provide important information to formulate effective marine emission control measures in the HKSAR**

Discussion and Conclusion (3/3)

- Areas for Improvement
  - AE and AB information are still inadequate for OGVs.
  - Only two weeks of vessel track data was used.
  - Detailed berthing location information and thus shifting emissions, though not significant, was not considered.
  - RVs operational and engine activity data were not as comprehensive as those of OGVs.

- Conclusion
  - A much improved marine vessels emission inventory, with spatial and temporal distribution, for 2007 was compiled based on HKUST study and EPD in-house survey.
  - A full time-series from 1990 to 2020 was estimated.
  - Air quality modelling and a general policy analysis are in progress to advise policymaker possible ways forward.

End of Presentation

Thank You