DNV·GL

MARITIME

Emissions from ships operating in the Sydney Greater Metropolitan Area

Report

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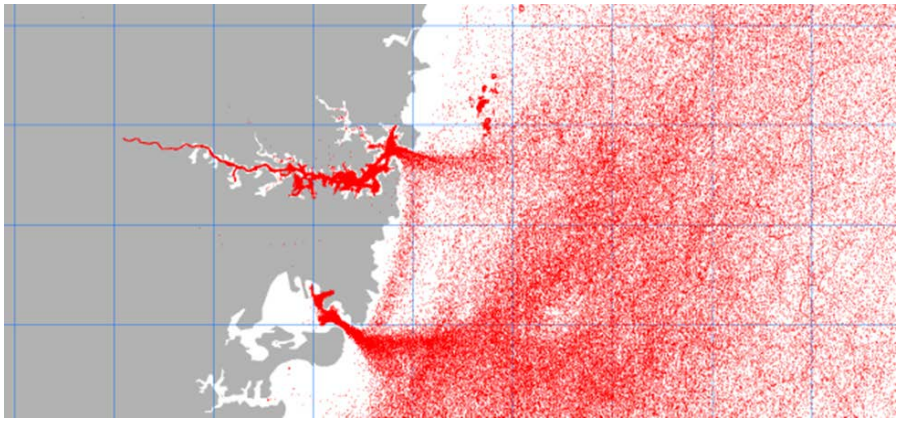
Agenda

- Introduction
- Methodology
- Emissions at berth versus in transit
- Emissions by ship type by GMA port
- Emissions forecasts
- Abatement technology, suitability and predicted uptake in GMA
- Conclusions

Introduction

DNV GL commissioned to produce a report that covered details including (but not limited to):

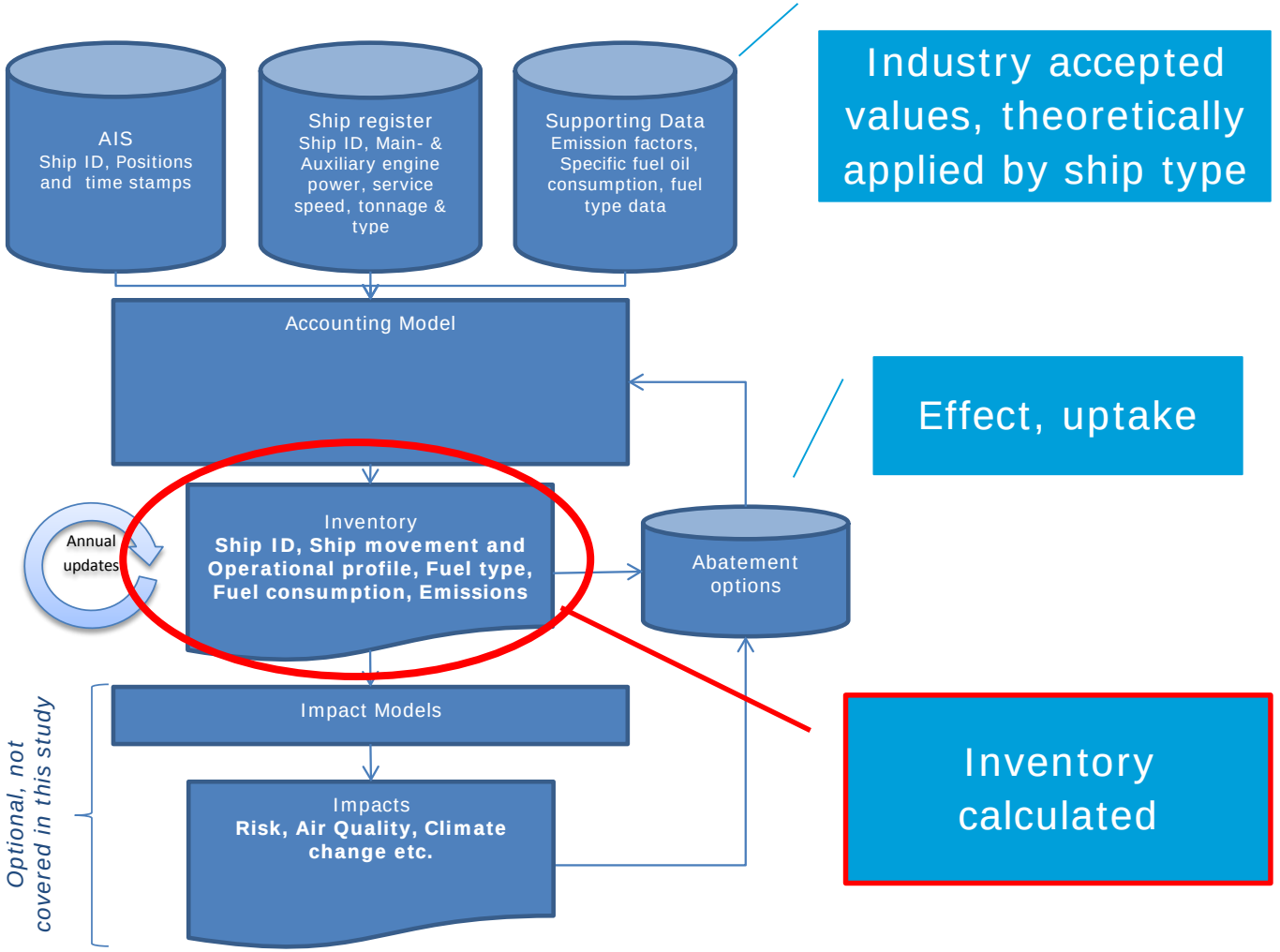
- Emission ‘hot spots’ in the GMA
- Current and projected ship movements
- Ship capabilities for using emission reduction measures
- Feedback from stakeholders in the maritime supply chain including ship owners, operators, suppliers, regulators, ports and other interested parties



2013 AIS data for a GMA section outside Sydney with 0.1 degree grid

Methodology – emissions accounting

Position taken every 6 minutes to calculate SOG



Industry accepted values, theoretically applied by ship type

Effect, uptake

Inventory calculated

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Emissions calculations process - GMA

Ship type	Number of unique ships							
	<1000 GT	1000 - 4999 GT	5000 – 9999 GT	10000-24999 GT	25000-49999 GT	50000-99999 GT	≥ 100000 GT	Totals
Oil tankers		5	12		79	65		161
Chemical/Prod tankers		2	35	17	58			112
Gas tankers		8	3		18			29
Bulk carriers			1	199	656	503	15	1374
General cargo vessels		6	91	68	15			180
Container vessels			6	22	169	68		265
RoRo vessels			2	1	56	145		204
Reefers		4		1				5
Passenger vessels	4	1			12	20	4	41
Offshore supply vessels	2	5						7
Other offshore service vessels			1				1	2
Other activities	61	7	2	2				72
Totals	67	38	153	310	1063	801	20	2452

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Ship count

Ship type	Operational hours							
	<1000 GT	1000 - 4999 GT	5000 – 9999 GT	10000-24999 GT	25000-49999 GT	50000-99999 GT	≥ 100000 GT	Totals
Oil tankers		29034	11157		50144	14946		105281
Chemical/Prod tankers		1940	13519	2803	33319			51581
Gas tankers		5223	7487		2251		0	14961
Bulk carriers			459	29549	198724	179617	5874	414224
General cargo vessels		3277	23014	24180	13362			63833
Container vessels			4324	8879	59353	27422	49	100027
RoRo vessels			143	8	5285	12994		18431
Reefers		60	1	1				62
Passenger vessels	52837	24566			1554	9558	1395	89910
Offshore supply vessels	842	174						1015
Other offshore service vessels			7741				0	7742
Other activities	259980	10307	406	1829				272522
Totals	313,659	74,580	68,251	67,249	363,992	244,537	7,319	1,139,588

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Ops profile

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Emissions calculations - GMA

Ship type	Fuel consumption (metric tonnes)			
	Main engines	Auxiliary engines	Boilers	Totals
Oil tankers	7862	13185	17903	38950
Chemical/Prod tankers	5089	7965	4256	17310
Gas tankers	960	1645	907	3513
Bulk carriers	49270	31281	9898	90449
General cargo vessels	5735	5478	1648	12860
Container vessels	24631	26600	11852	63082
RoRo vessels	7100	2795	380	10275
Reefers	24	3	0	27
Passenger vessels	19640	6935	2429	29004
Offshore supply vessels	38	49	0	88
Other offshore service vessels	307	869	832	2008
Other activities	1997	3227	198	5422
Totals	122,653	100,032	50,303	272,988

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Fuel consumed

Ship type	Emissions (metric tonnes)			
	CO_2	NOx	SO_2	$PM_{2.5}$
Oil tankers	124198	1341	2047	202
Chemical/Prod tankers	55083	748	920	96
Gas tankers	11169	138	170	17
Bulk carriers	288436	5490	4883	553
General cargo vessels	40809	658	686	74
Container vessels	201002	3277	3406	370
RoRo vessels	32788	706	555	65
Reefers	86	1	1	0
Passenger vessels	92225	1787	1365	158
Offshore supply vessels	277	4	1	0
Other offshore service vessels	6390	60	40	6
Other activities	17184	233	88	10
Totals	869,649	14,443	14,162	1,553

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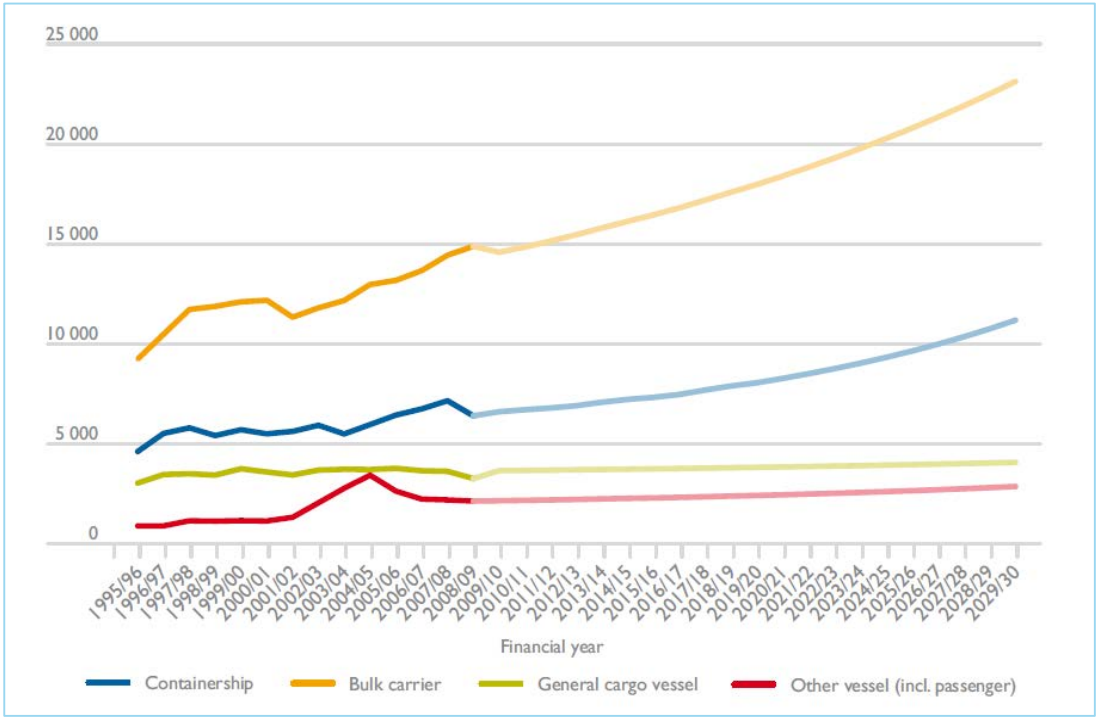
Emissions

Methodology – forecasting trade / traffic

- The main source for this assessment is a report published by Bureau of Infrastructure, Transport and Regional Economics (BITRE) in 2010 (2). Other industry specific sources, where considered reliable, were also included in final calculations.



Historical and forecasted number of calls to Australian ports, per main ship category

Methodology – forecasting emissions

- Reference to:
  - forecasted ship traffic increase in NSW (BITRE)
  - Forecasted emission profile for global shipping presented in IMO's Second GHG (2009)
  - Assumed that PM2.5 emissions will follow the SOx emission curve, with 80% and 96% reduction for the 0.5% and 0.1% sulphur limit cases respectively

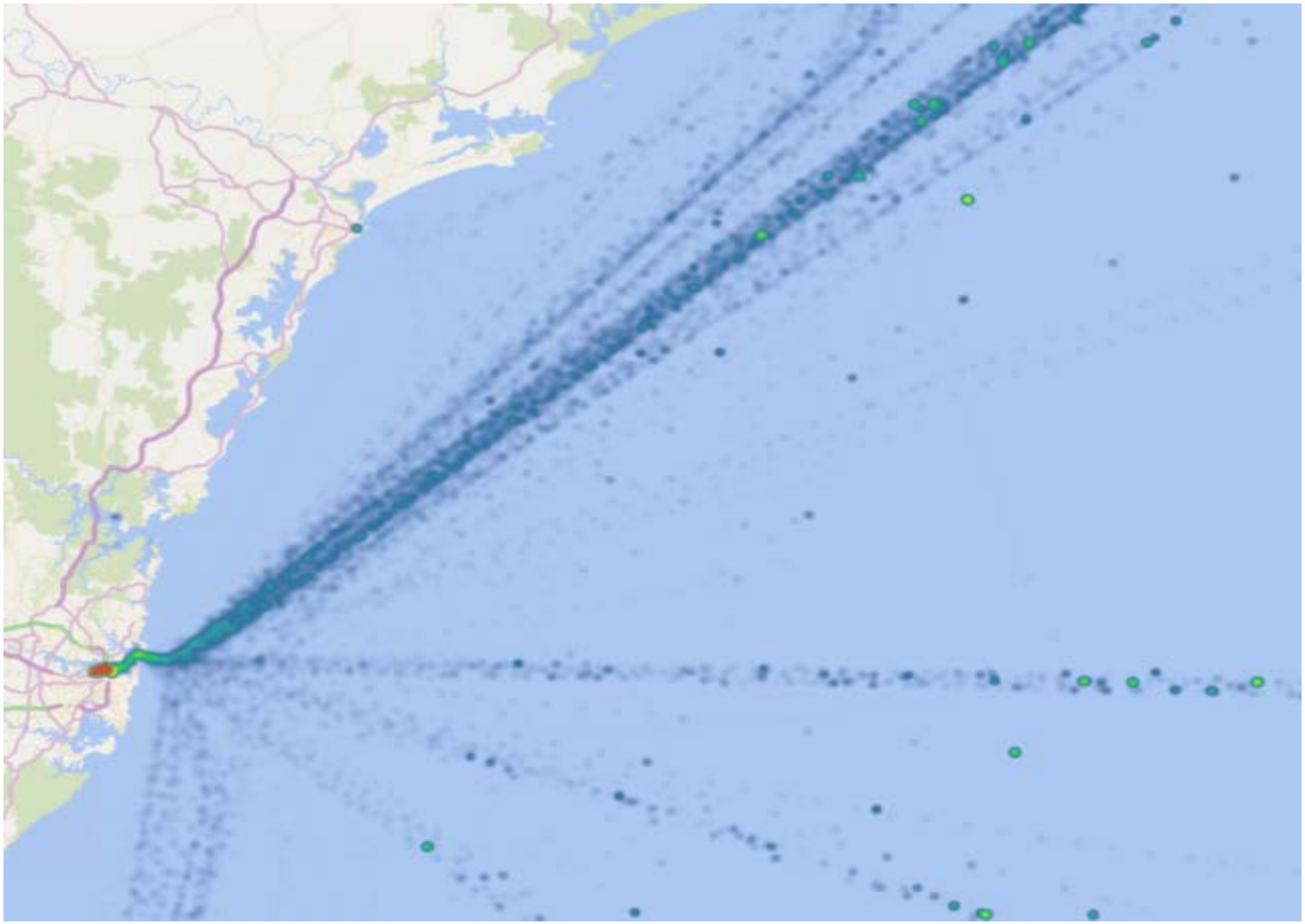
All ship emissions, BAU *(metric tonnes)*	**GMA**			
	CO_2	**NOx**	**SO_2**	**$PM_{2.5}$**
2013	869 649	14 443	14 162	1 553
2015	826 167	13 721	12 038	1 320
2017	869 649	12 999	12 746	1 398
2019	913 131	12 277	13 454	1 475
2020	930 524	12 421	2 691	295
2025	1 000 096	12 999	3 399	373
2030	1 043 579	13 721	4 107	450
2040	1 174 026	13 721	4 815	528

Emissions ‘at berth’ vs ‘in transit’

‘In terms of emissions (CO2, NOx, SOx and PM2.5), the large majority occurs outside the Port areas studied.’

	CO_2	NOx	SOx	PM2.5
TOTAL in the GMA (tonnes)	869,649	14,443	14,162	1,553
Port Jackson, share	3.9%	2.0%	3.5%	3.0%
Port Botany, share	10.3%	5.3%	10.5%	9.0%
Port of New-castle, share	4.5%	2.8%	4.3%	3.9%
Port Kembla, share	2.0%	1.3%	2.0%	1.8%
TRANSIT	**79.3%**	**88.6%**	**79.7%**	**82.3%**

Emissions ‘at berth’ vs ‘in transit’



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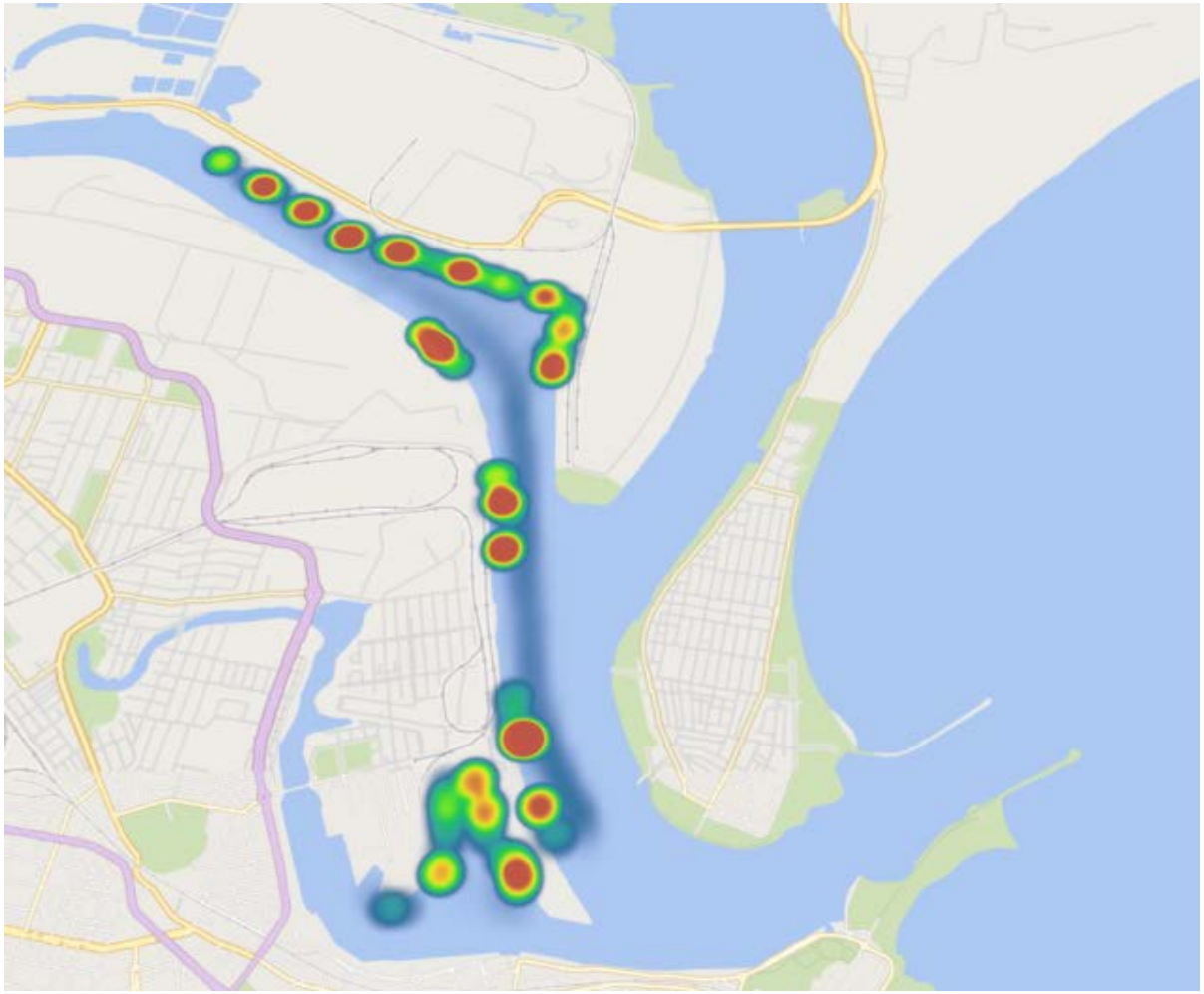
Emissions by ship type - Newcastle



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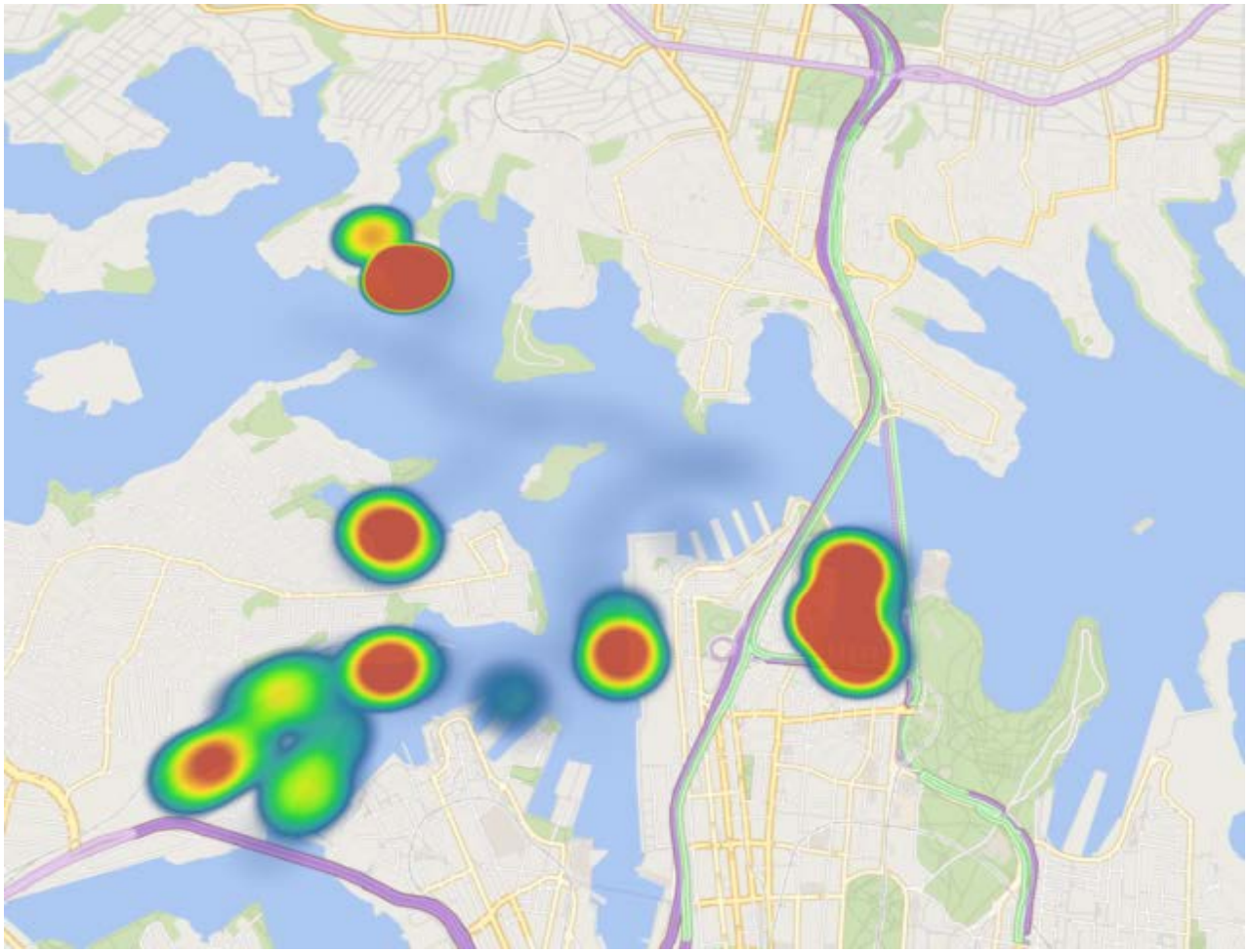
Emissions by ship type - Newcastle

Dominant segments:

1. Bulk carriers
2. Oil Tankers

Ship type	Emissions (metric tonnes)			
	CO_2	NOx	SO_2	$PM_{2.5}$
Oil tankers	7170	37	121	11
Chemical/Prod tankers	825	9	11	1
Gas tankers	658	5	11	1
Bulk carriers	21286	247	362	36
General cargo vessels	4849	53	81	8
Container vessels	477	4	8	1
RoRo vessels	165	2	3	0
Reefers	1	0	0	0
Passenger vessels	132	1	2	0
Offshore supply vessels	11	0	0	0
Other offshore service vessels				
Other activities	3145	44	13	2
Totals	38,719	402	612	60

Emissions by ship type – Port Jackson



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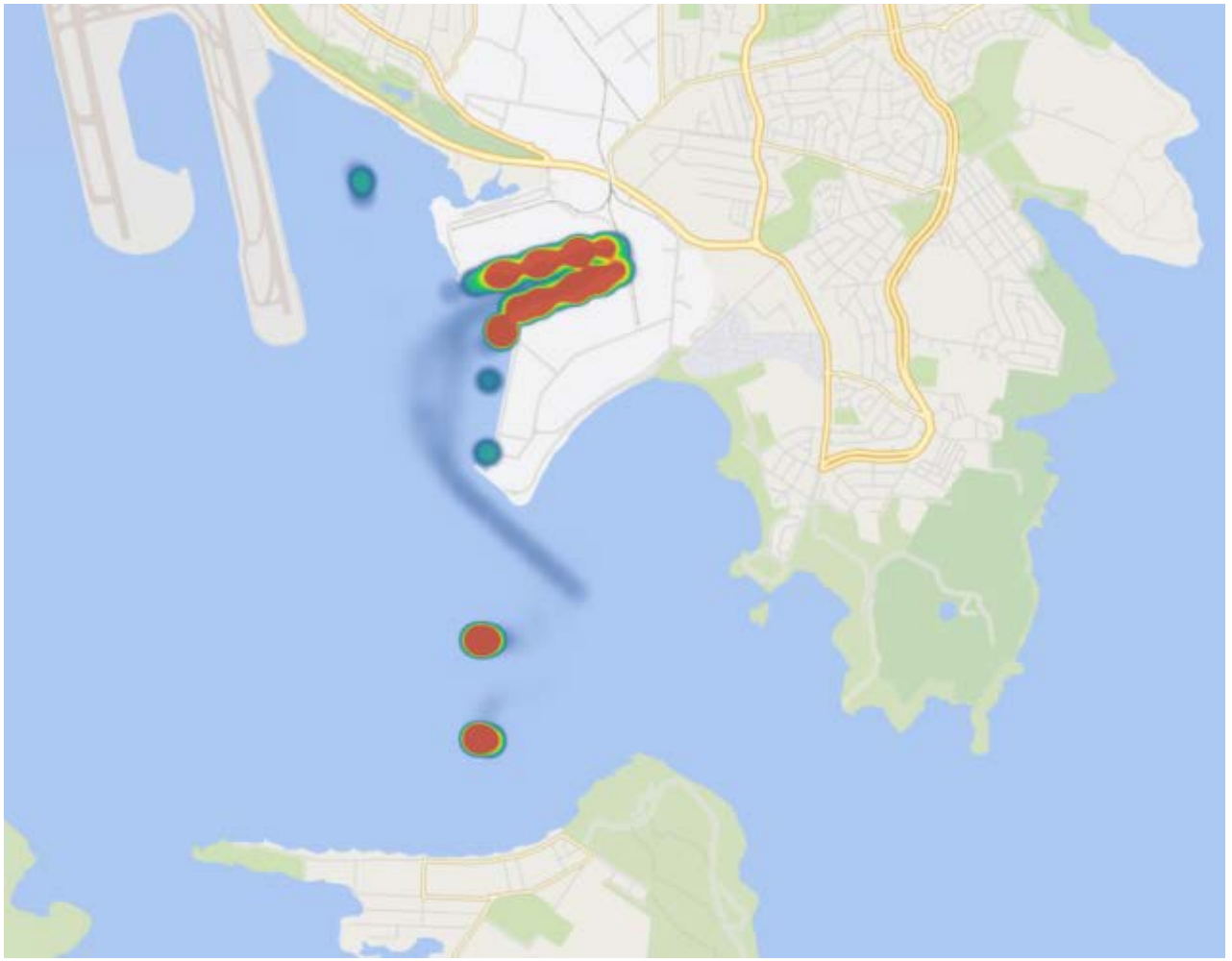
Emissions by ship type – Port Jackson

Dominant segments:

1. Oil tankers
2. Passenger

Ship type	Emissions (metric tonnes)			
	CO_2	NOx	SO_2	$PM_{2.5}$
Oil tankers	15729	83	247	21
Chemical/Prod tankers	3240	33	55	5
Gas tankers				
Bulk carriers	957	10	16	2
General cargo vessels	852	9	14	1
Container vessels	130	1	2	0
RoRo vessels				
Reefers				
Passenger vessels	11129	124	160	16
Offshore supply vessels				
Other offshore service vessels	422	3	3	0
Other activities	1346	19	4	1
Totals	33,804	283	502	47

Emissions by ship type – Port Botany



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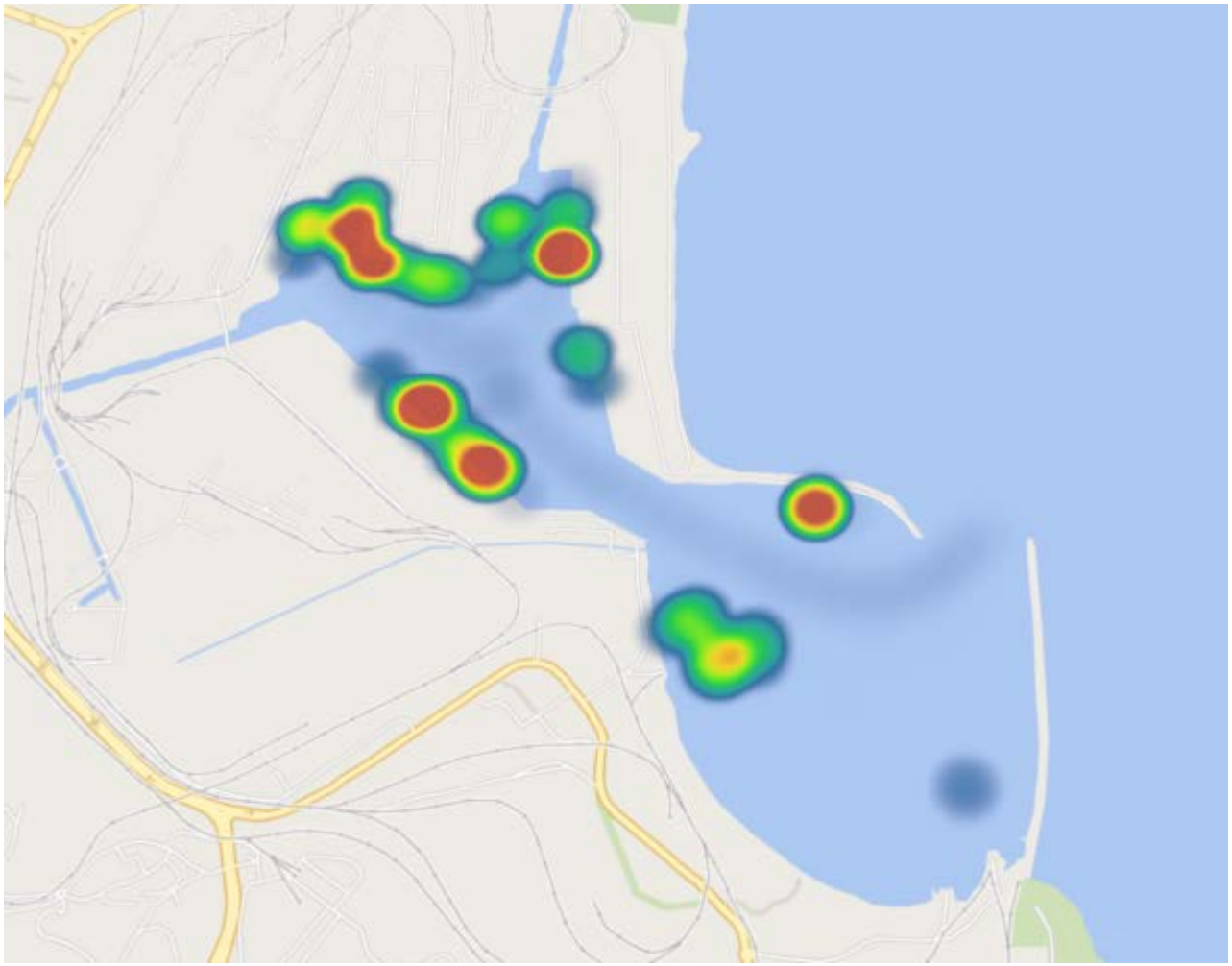
Emissions by ship type – Port Botany

Dominant segments:

1. Container
2. Oil tankers

Ship type	Emissions (metric tonnes)			
	CO_2	NOx	SO_2	$PM_{2.5}$
Oil tankers	31163	154	511	44
Chemical/Prod tankers	4450	43	76	7
Gas tankers	1187	12	19	2
Bulk carriers	1	0	0	0
General cargo vessels	234	3	4	0
Container vessels	51349	545	872	86
RoRo vessels				
Reefers				
Passenger vessels				
Offshore supply vessels				
Other offshore service vessels				
Other activities	868	12	3	0
Totals	89,252	769	1,484	140

Emissions by ship type – Port Kembla



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Emissions by ship type – Port Kembla

Dominant segments:

1. Bulk carriers
2. Ro Ro

Ship type	Emissions (metric tonnes)			
	CO_2	NOx	SO_2	$PM_{2.5}$
Oil tankers	1378	6	23	2
Chemical/Prod tankers	270	3	4	0
Gas tankers	4	0	0	0
Bulk carriers	8217	94	140	14
General cargo vessels	2974	33	51	5
Container vessels	113	1	2	0
RoRo vessels	3461	48	59	6
Reefers				
Passenger vessels				
Offshore supply vessels				
Other offshore service vessels				
Other activities	584	8	2	0
Totals	17,002	192	280	28

Forecast emissions - BAU

BAU (business as usual) defined as:

- planned/known regulatory measures

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- no NSW-specific emission reduction measures implement (of any kind)

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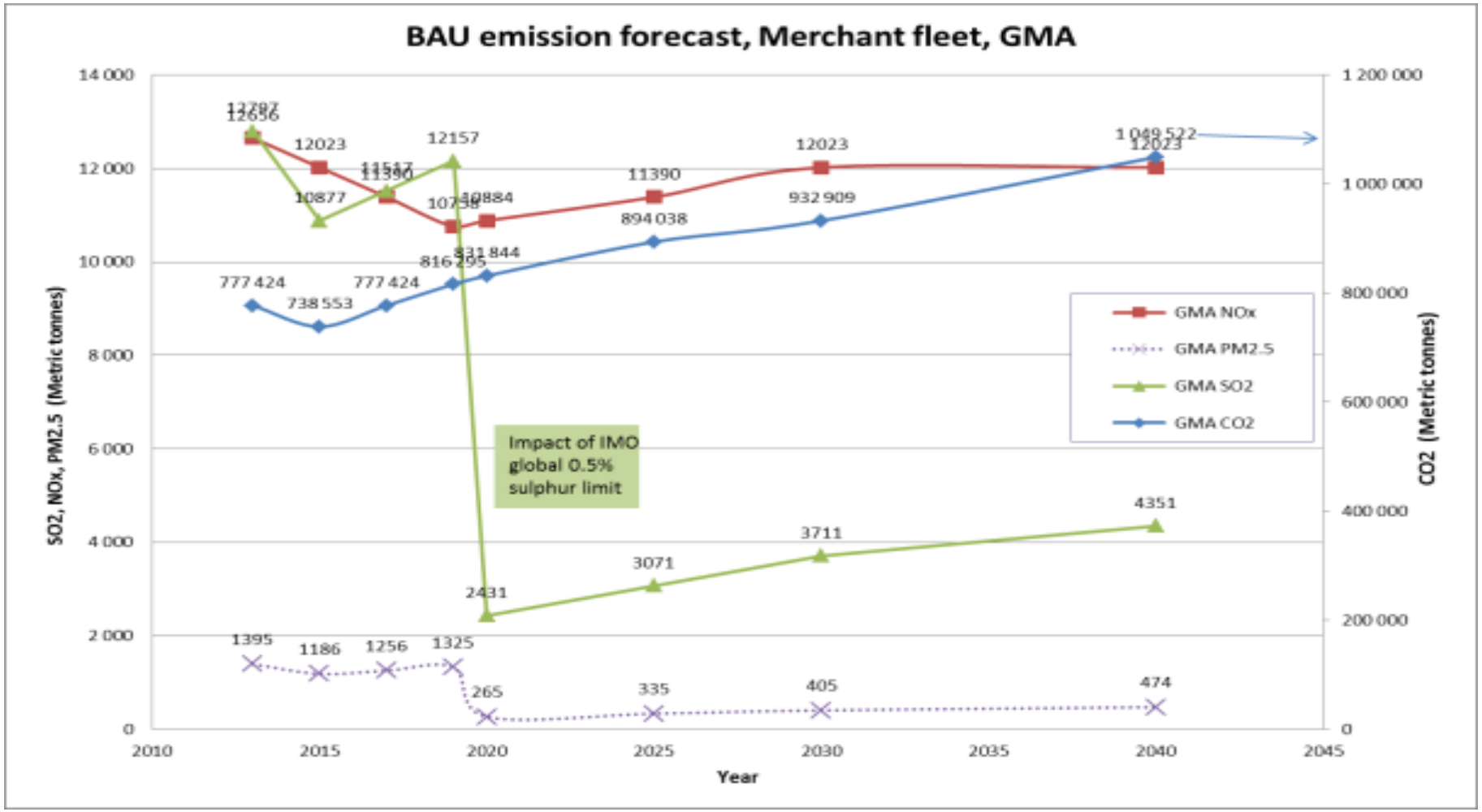
- estimated uptake in voluntary abatement initiatives

Forecast emissions - BAU



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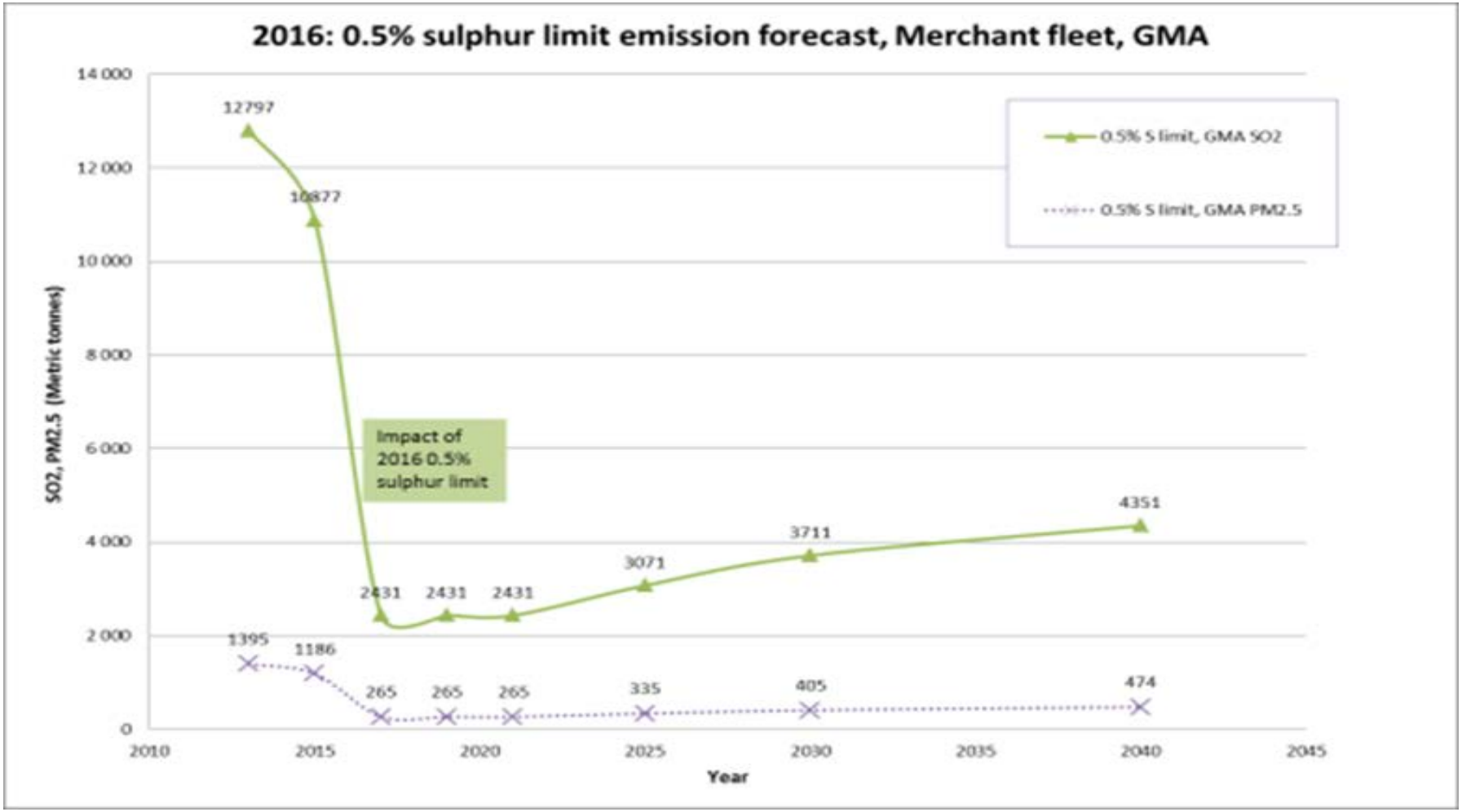
Forecast emissions – NSW specific scenarios from 2016

- Various NSW-specific scenarios were modelled
  - 0.5% sulphur limit
  - 0.1% sulphur limit
- Incorporated planned/known regulatory measures and estimated uptake of voluntary abatement initiatives

Forecast emissions – NSW specific scenarios from 2016



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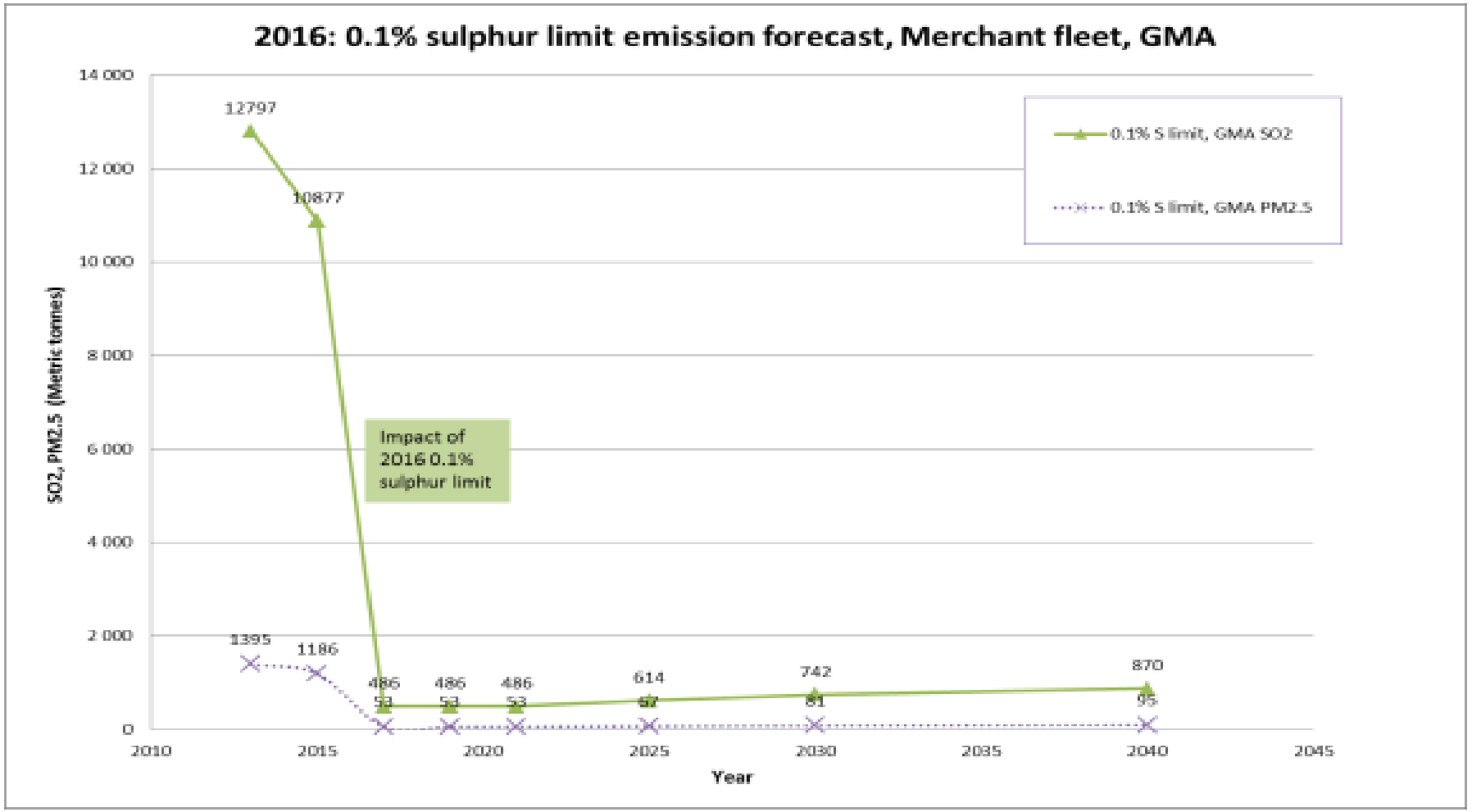
Forecast emissions – 0.1% from 2016



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Abatement measures – in general

Abatement option:	NOx reduction	SOx reduction	CO2 reduction	PM reduction
Slow steaming	Limited saving potential inside GMA because ships already sail slowly.			
Low Sulphur Distillates	-	~80% - ~96%	-	Approx. 90%
Scrubber (wet)	-	90-95%	1.5-2% increase	80-90%
Shore-side power	~96% reduction achievable for all emission components			
SCR	4-stroke: 90% typically	-	Slight increase	20-40%
LNG as fuel	90% - 40%	90-100%	Approx. 15%	More than 90%
EGR	35-40%	-	Slight increase	Slight increase
Direct water injection	20-40% typical	-	Increased	-
HAM / Humid Air Motor	20-40% typical	-	-	-
Engine Modification	20-40%	-	Slight increase	Marginal reduction

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Abatement technology - GMA uptake (1/2)

Option	Estimated realistic uptake by ships in AUS by 2017	Estimated realistic uptake by ships in AUS by 2020
Various technical and operational measures primarily to curb emission reduction <u>while sailing</u>	General focus on fuel efficiency will continue to grow	• Most ship operators • EEDI requirements will significantly reduce fuel consumption for new ships.
Various technical and operational measures primarily to curb emission reduction <u>while at berth</u>	Nothing unless enforced by law or fiscal stimuli (shore power etc.).	Some technology uptake may be registered in ships originating in EU or the US.
LNG as fuel	More or less absent	Few
Switch to 0.5% Low Sulphur Distillates	Not unless required.	Dominant solution

Abatement technology GMA uptake (2/2)

Option	Estimated realistic uptake by ships in AUS by 2017	Estimated realistic uptake by ships in AUS by 2020
Scrubbers	Only ships that are trading in ECAs.	HFO+scrubber will be an attractive solution to meet IMO Global sulphur limit
Shore-side power	Not considered a widely used solution by 2017.	Limited uptake
SCR **EGR** **Direct Water Injection** **HAM** **Engine Modifications**	All these are NOx reducing measures If no NOx specific emission regulation regime is planned no significant uptake	

Conclusions …

- Emissions from shipping in GMA are a reality
- Lower sulphur fuel requirements will realise a significant reduction in SOx and PM2.5 but not really impact CO2 nor NOx
- Shore-side power is technically feasible but requires prohibitive CAPEX on shore and long lead time

And issues to be considered …

- Timing – IMO global sulphur limit due in 2020/25
- Lead time – for ship owners/operators to install/upgrade for abatement
- Enforcement – responsibility to check/pass/penalise

Questions?

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