



Lean and clean dredging for a better future

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Presented by Leo W. van Ingen, August 26th

WEDA 33 & TAMU 44

Preface

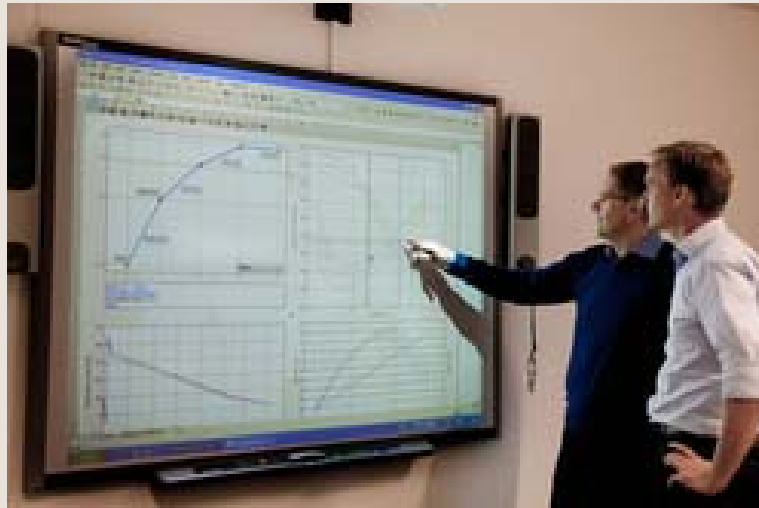
Why this paper?

- IHC has subsidiaries such as:
 - TID (Training Institute for Dredging),
 - MTI (Mineral Technological Institute),
 - DAS (Dredging Advisory Services).



TID, MTI & DAS:

- When it comes to lean and clean dredging:
 - It is not a matter of making emission legislations only,
 - It is not a matter of translation of these rules and regulation into complying power generation systems only,
 - It is not a matter of developing innovative dredge equipment only.

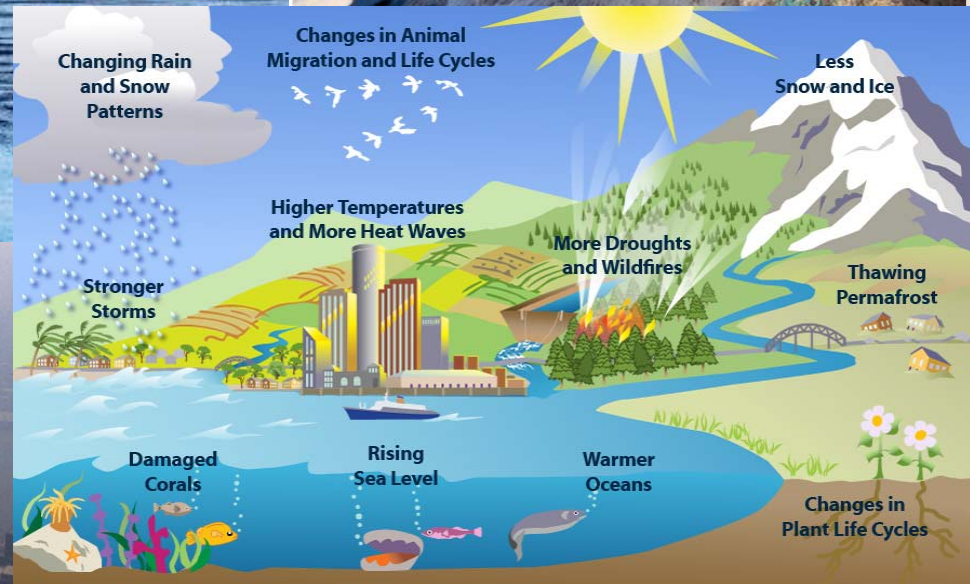


Topics

- Introduction
- Why do we have emission control
- The IMO / EPA in a nutshell
- Be keen on inconsistencies in regulations
- Innovative solutions and appliances from industry
- Emission reduction by Project, People and proper use of Equipment
- Conclusions

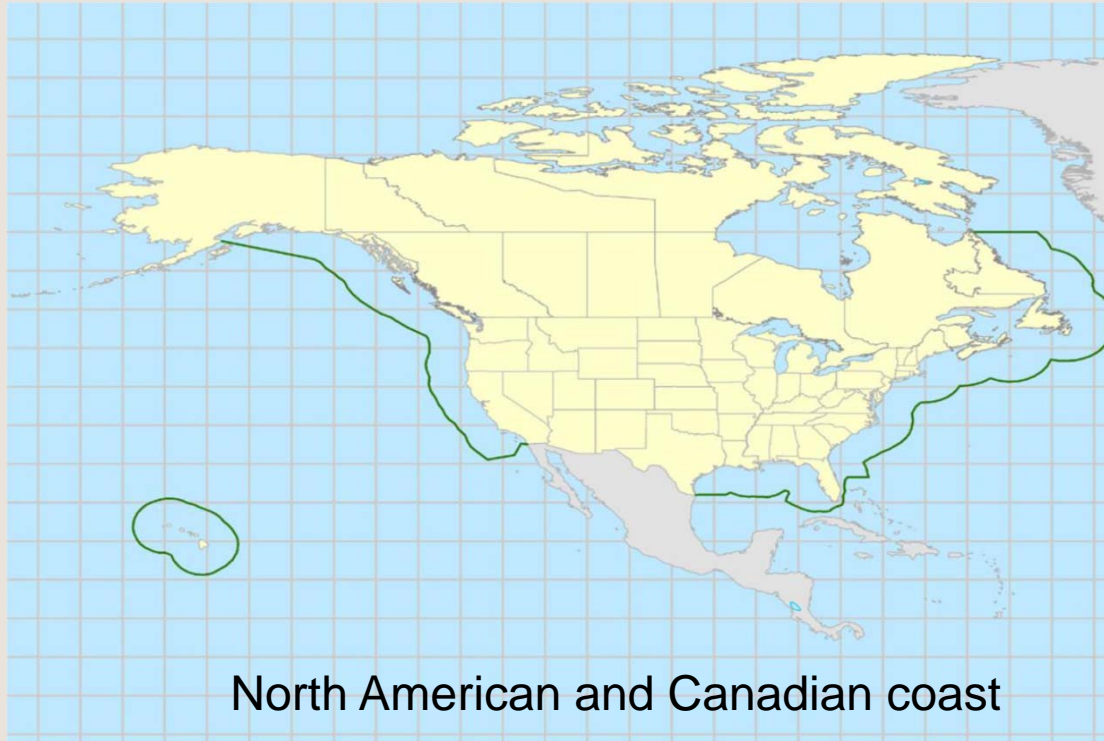


Why do we have emission legislations ?

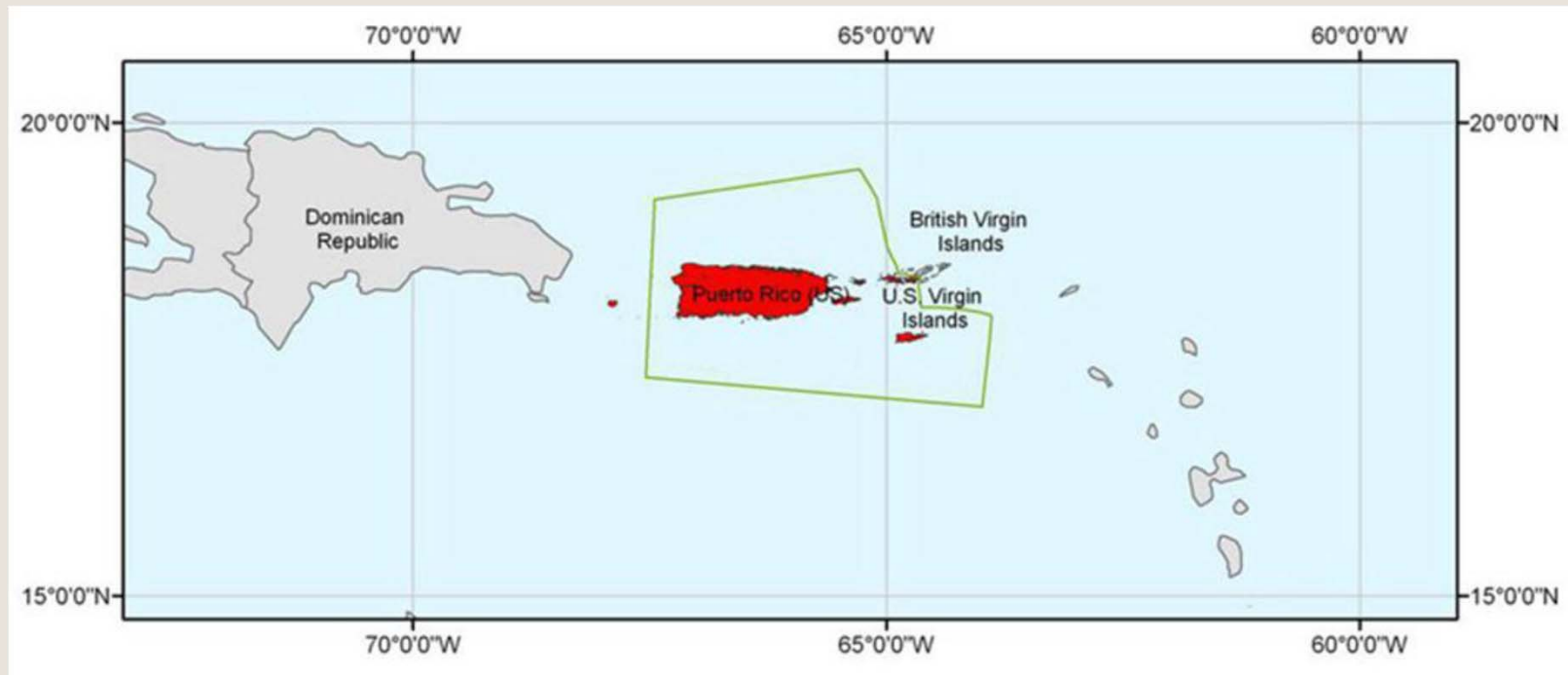


Emission legislation, update and trends (July 2013)

IMO (International Maritime Organization) established world emission regions, so called ***Emission Control Areas***



North American and Canadian coast



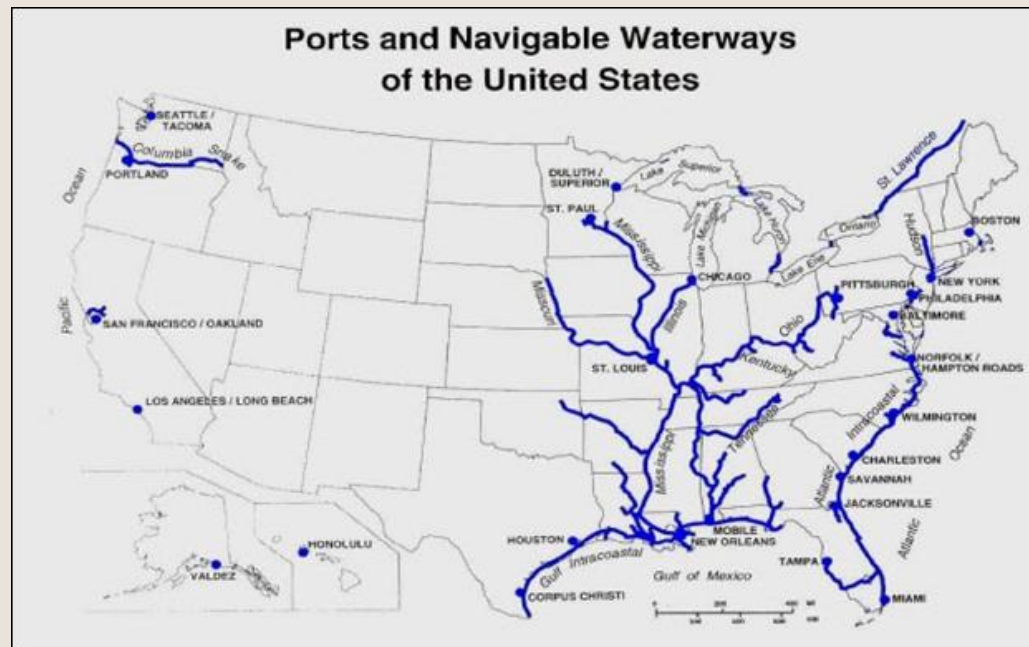
US Caribbean ECA (Puerto Rico & US Virgin Islands)

IMO's defined Particularly Sensitive Sea Areas (PSSA's)

- PSSA's are areas that need special protection due to ecological, socio-economic or scientific reasons, areas vulnerable to be damaged by international maritime activities. US PSSA's are a.o:
- The sea around Florida Keys
- The Papahānaumokuākea Marine National Monument



Inland waterways



Vessels/units navigating the whole US inland waterways are subject to specific emission limits as set by EPA.

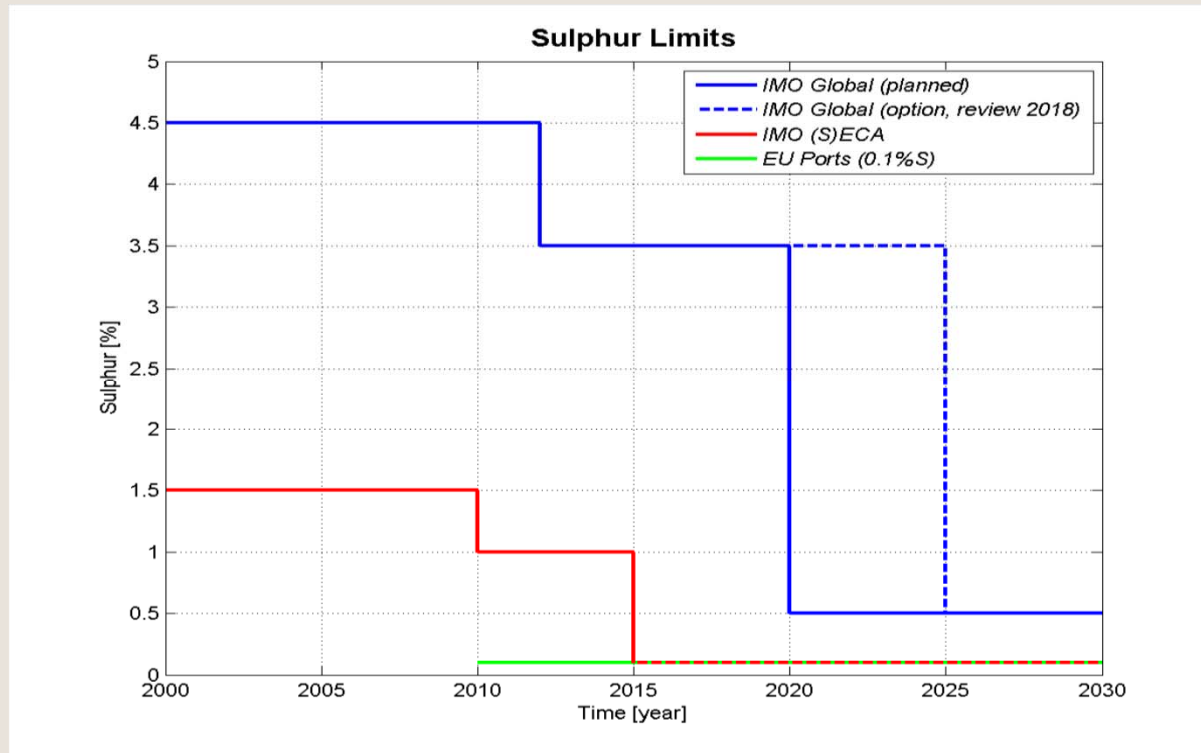
Ocean going vessels/units exempt from EPA.

IMO legislations for ocean going vessels

- Regulated emission norms
 - Sulphur oxides (SO_x)
 - Nitrogen (NO_x)
 - Carbon dioxide (CO₂)
- Futurised:
 - Black Carbon



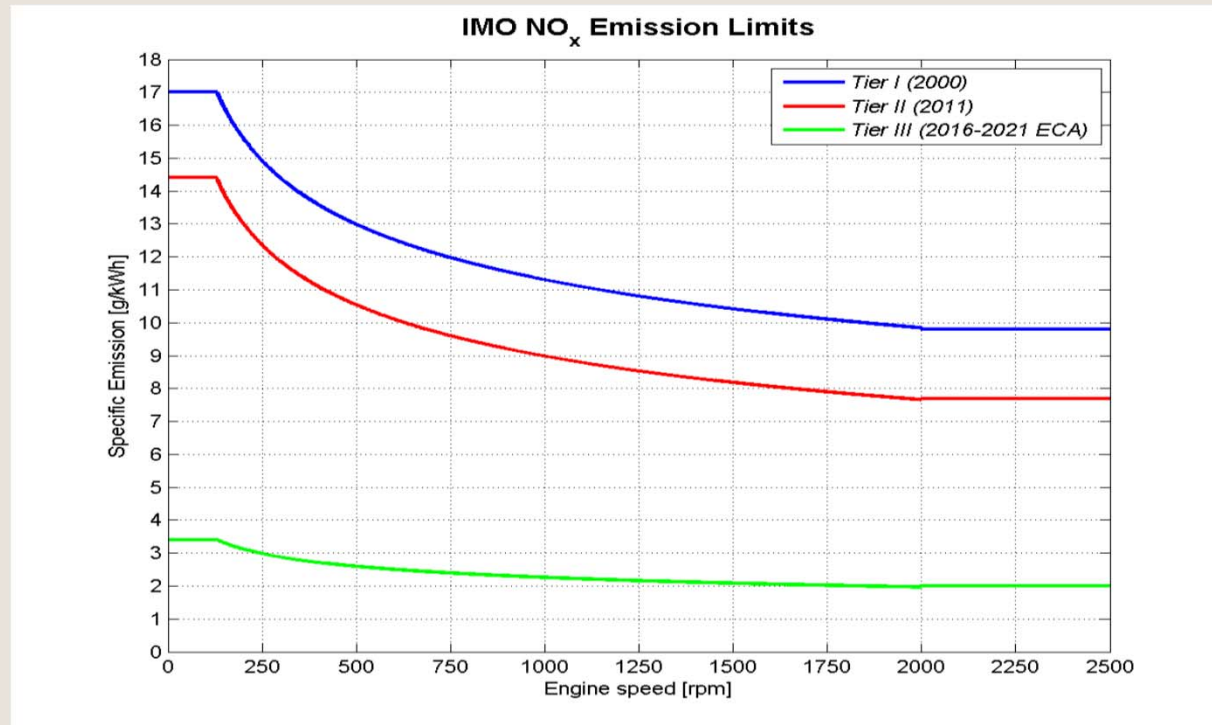
Sulfur Oxides



Seagoing vessels/units, (S)ECA's or ports may even be more stringent.

In practice: ***Vessels/Units must either use low Sulphur fuels or need scrubber technique to reduce emission levels in (S)ECA's and ports***

Nitrogen Oxides



In practice: **Diesel engines cannot comply and SCR technique is required to reduce emissions to the levels required in the (N)ECA's (for new build vessels/units) or switch to gas engines.**

Carbon Dioxide

IMO has recently started with legislation for CO₂ emissions and is regulated in the form of:

- Energy Efficiency Design Index (EEDI)
- Ship Energy Efficient Management Plan (SEEMP)

$$EEDI = \frac{\text{CO}_2 \text{ emission (g)}}{\text{transport work (tonne}\cdot\text{nm)}}$$

EEDI for dredging equipment is so far excluded however an alternative EEDI for dredging units is being discussed now and expected to be in place soon.



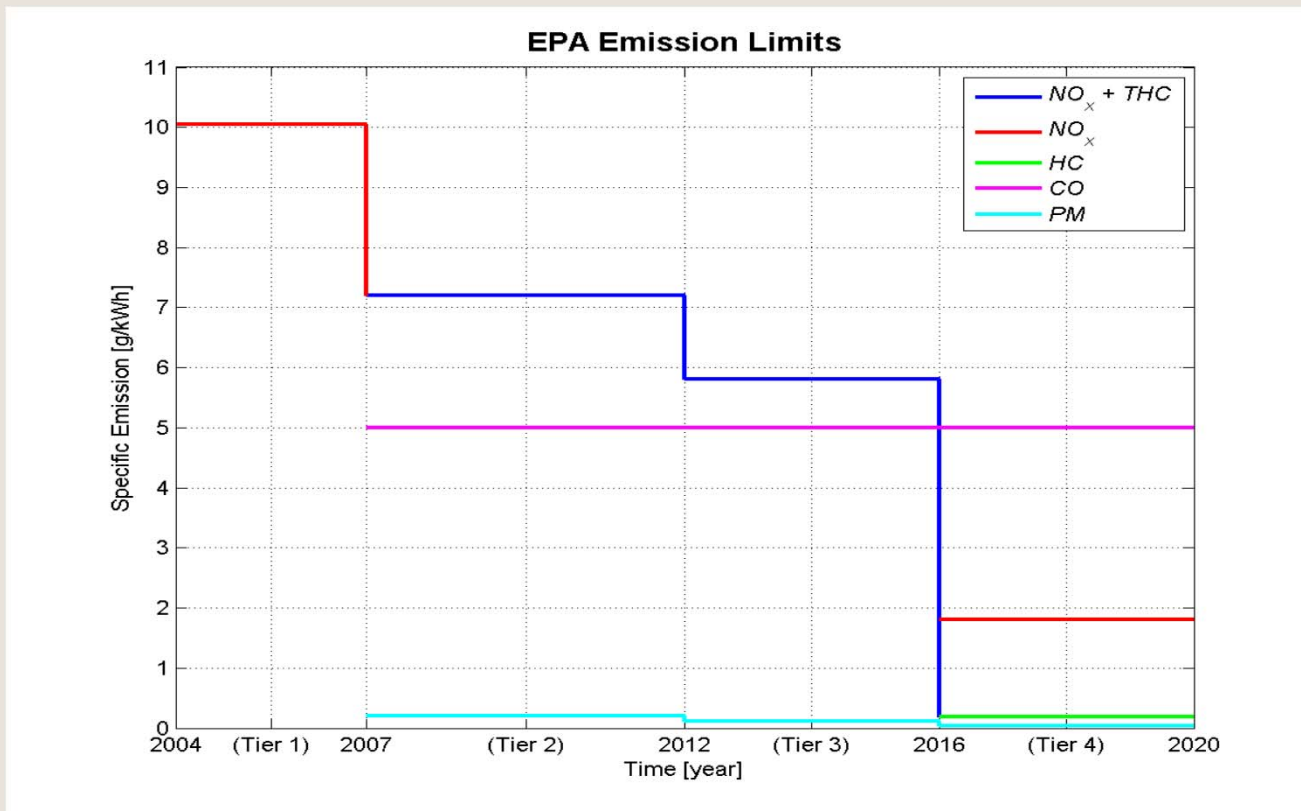
Emission levels for inland shipping

Legislation depend on cylinder volume, rpm and power density

- Regulated emissions are:
 - Sulphur oxides (SO_x)
 - Nitrogen oxides (NO_x)
 - Carbon monoxide (CO)
 - Total hydrocarbons (THC) or non-methane hydrocarbons (NMHC)
 - Particulate matter (PM)



Figure showing the US based EPA emission limits.



US based EPA emission limits.

- EPA (US based) has currently the strictest emission limits at EPA Tier 3.
- EPA currently has set limits for Tier 4 (2016), EU and CCNR currently have not.
- The EU is still at stage IIIA which is comparable with EPA Tier 2.



Emission compliance options: Yes we can, but ...

Industry has worked hard to comply with most of emission legislations, adopting emission control technology such as:

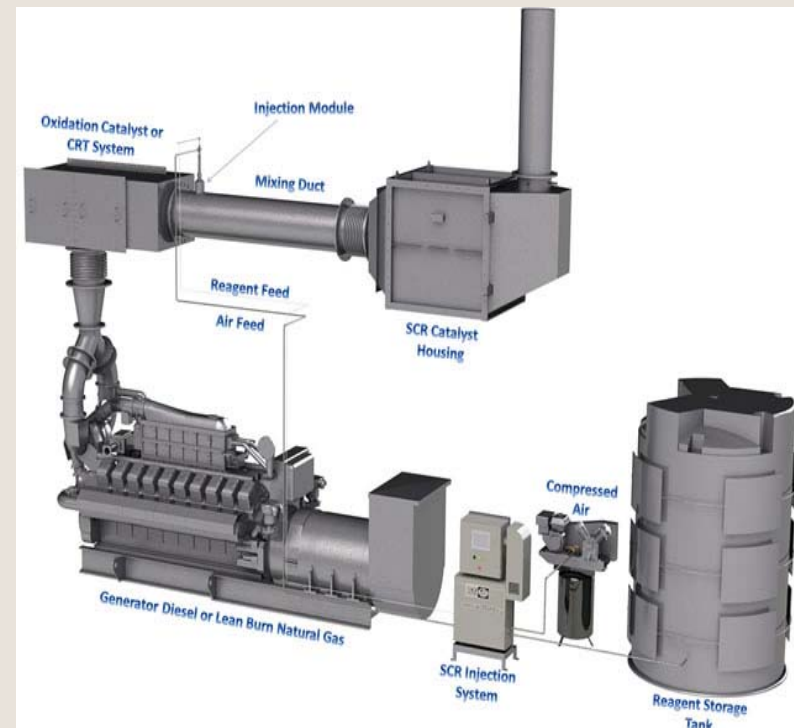
- For sulphur oxides (SO_x): Low sulfur fuels, Gas or Scrubbers
- For nitrogen oxides (NO_x); Gas or SCR's (Selective Catalytic Reduction)
- For carbon monoxide (CO) and hydrocarbons (HC): Engine control and/or Catalysts
- For particulate matter (PM): Gas or Particulate filters



SCR (Selective Catalytic Reduction) seems to be most promising now (system is still under development).

In practice, an IMO tier III/ EPA tier 4 engine requires:

- additional space and equipment on board,
- consumables (e.g. urea) and
- will consume in total about **10%** more fuel compared to IMO Tier I/ EPA Tier 1 power supply system,
- With heavy fuel oils, even scrubbers are required,
- Dollars & Crew training



Effect of exhaust gas treatment: inconsistencies of “end-of-pipe” solutions

“End-of-pipe” solutions, such as SCR do not necessarily lead to a truly more sustainable environment.

- The emission limits for the various pollutants have been introduced one by one.

But we have to approach the challenging problems in an integral way, the so-called *systems perspective*, which has been introduced in the 80's by [Checkland 1981]. It claims that a system can only be well understood when the interactions of all its components are taken into account.

For example, specific emission legislation as for NO_x cannot be isolated from other aspects.

Industrial Ecology and LCA (**Life Cycle impact Assessment**) calculation methods, Recipe 2008 [Goedkop et. al 2009], and combine it with the *Ecoinvent* database show remarkable results:

Results of LCA scan

A scan LCA was performed, modeling a Tier III compliant vessel with a SCR (that reduced exhaust gas NOx emissions by 80%), taking into account the additional 10% fuel consumption and was compared with the base case (IMO Tier I vessel).

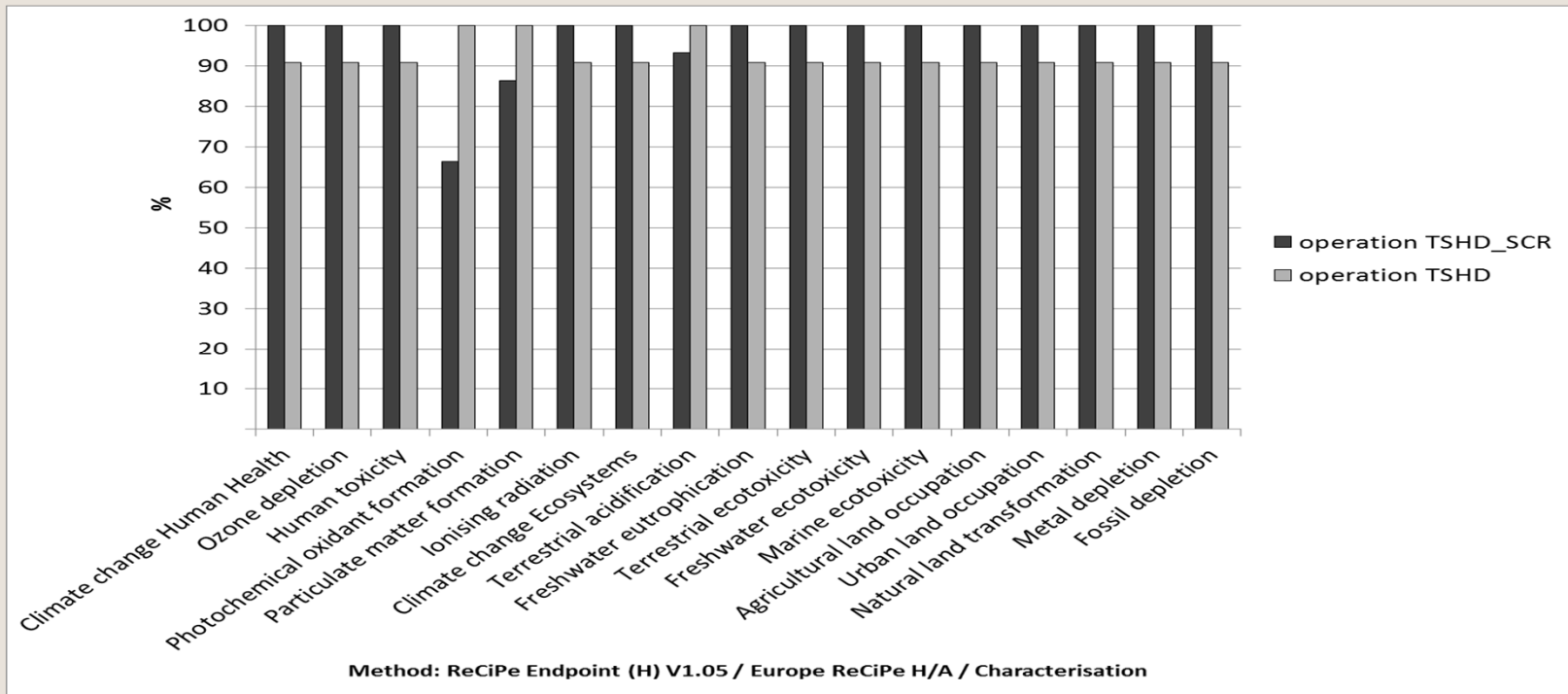
Results:

<i>Substance</i>	<i>Compartment</i>	<i>Unit</i>	<i>Heavy Fuel Combustion</i>	<i>Heavy Fuel Combustion+ SCR (80% Lower NOx)</i>
Nitrogen	Water	mg	3,86	3,86
Nitrogen oxides	Air	g	1,68	0,34
Nitrogen, organic bound	Water	mg	13,81	13,81

Inventory of emission values of the emissions of Nitrogen compounds to air and water, per liter of fuel used (heavy fuel emission data).

But,

Despite the NOx emissions into the air per liter burned fuel decreased, the Tier I vessel had a lower environmental impact over the whole LCA system.



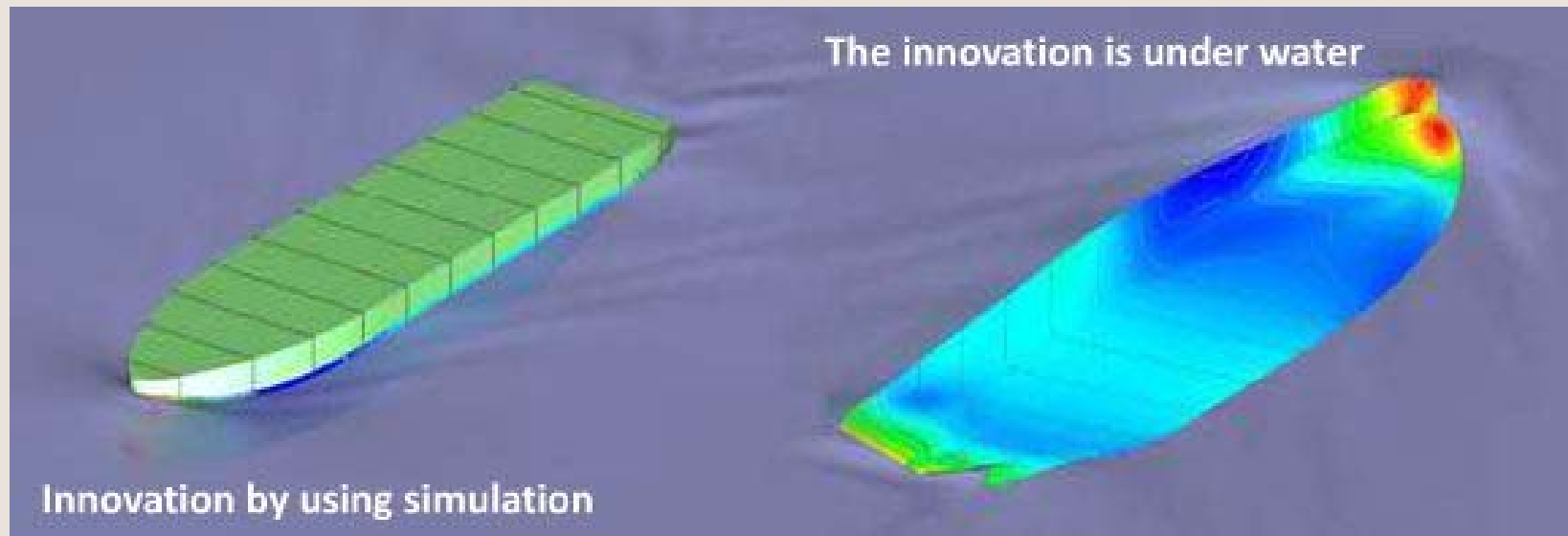
What can we learn from this?

Do we have to take care for lower emissions or shall we aim for a better environment?



There are more ways to reduce exhaust of pollutants

Lower emission per yd^3 means lower fuel per yd^3 .



Wave making resistance reduction by bulbous bow

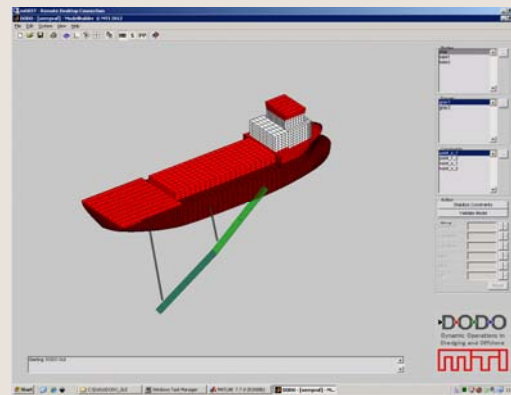


Dredge pump

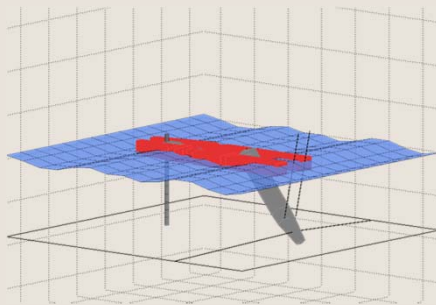
Dredge in operations the dredge pump is the main energy consumer.



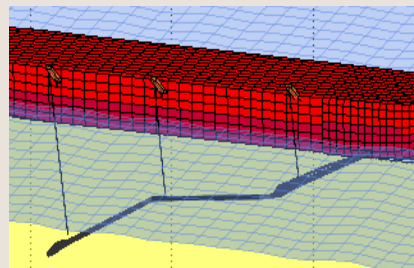
DODO (Dynamic Operations in Dredging and Offshore)



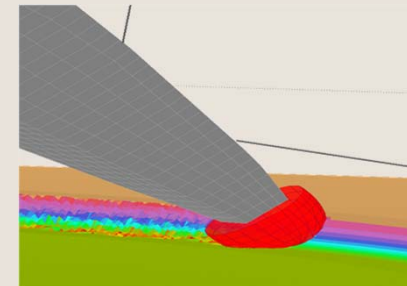
Hydrodynamics



Multibody dynamics



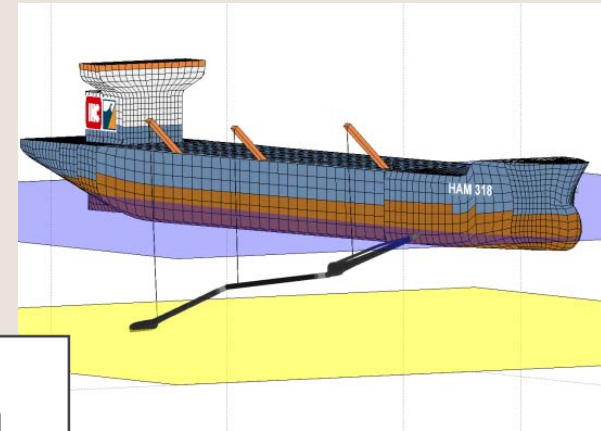
Soil mechanics



DODO for hopper dredges



Hopper



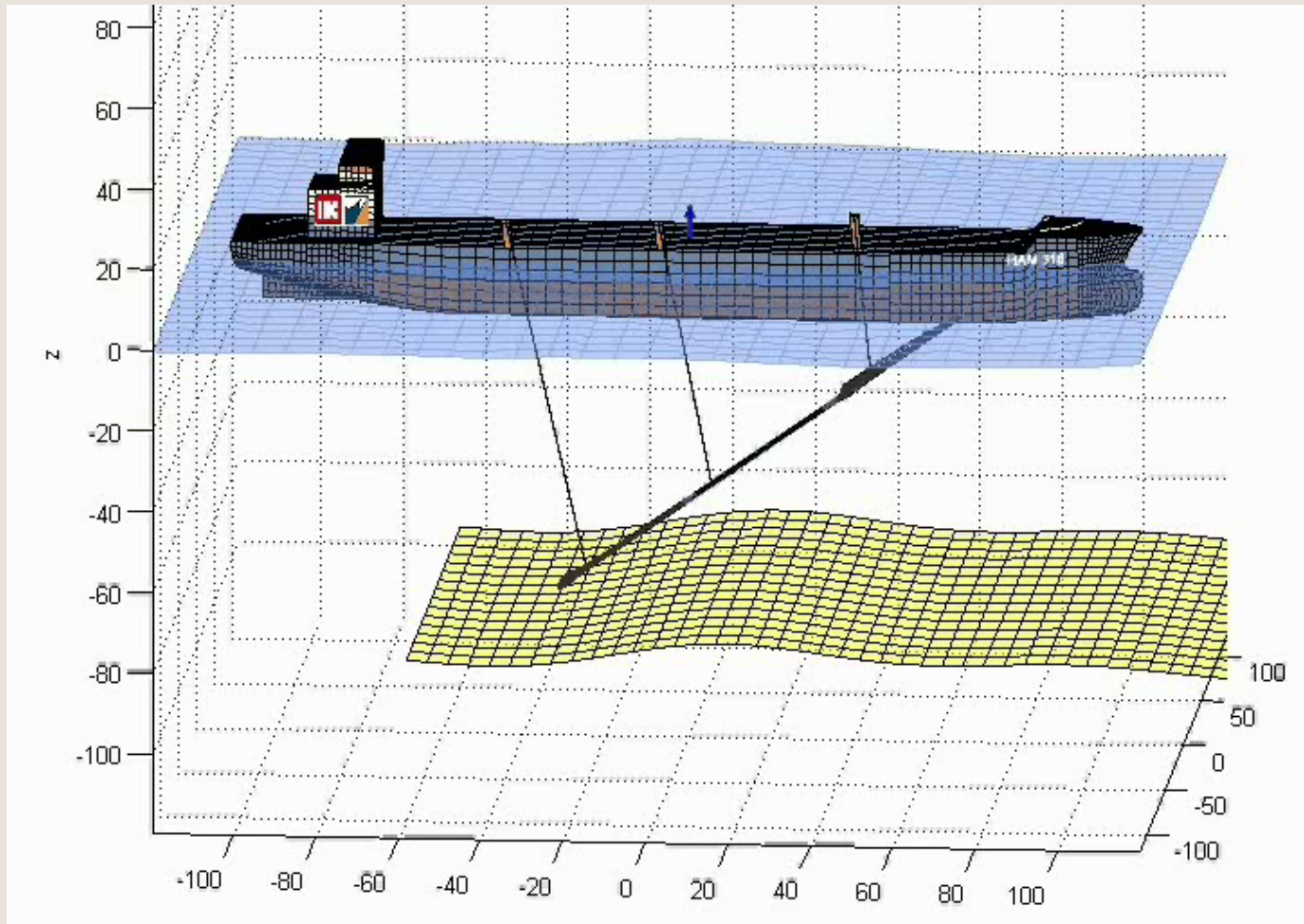
Simulation model

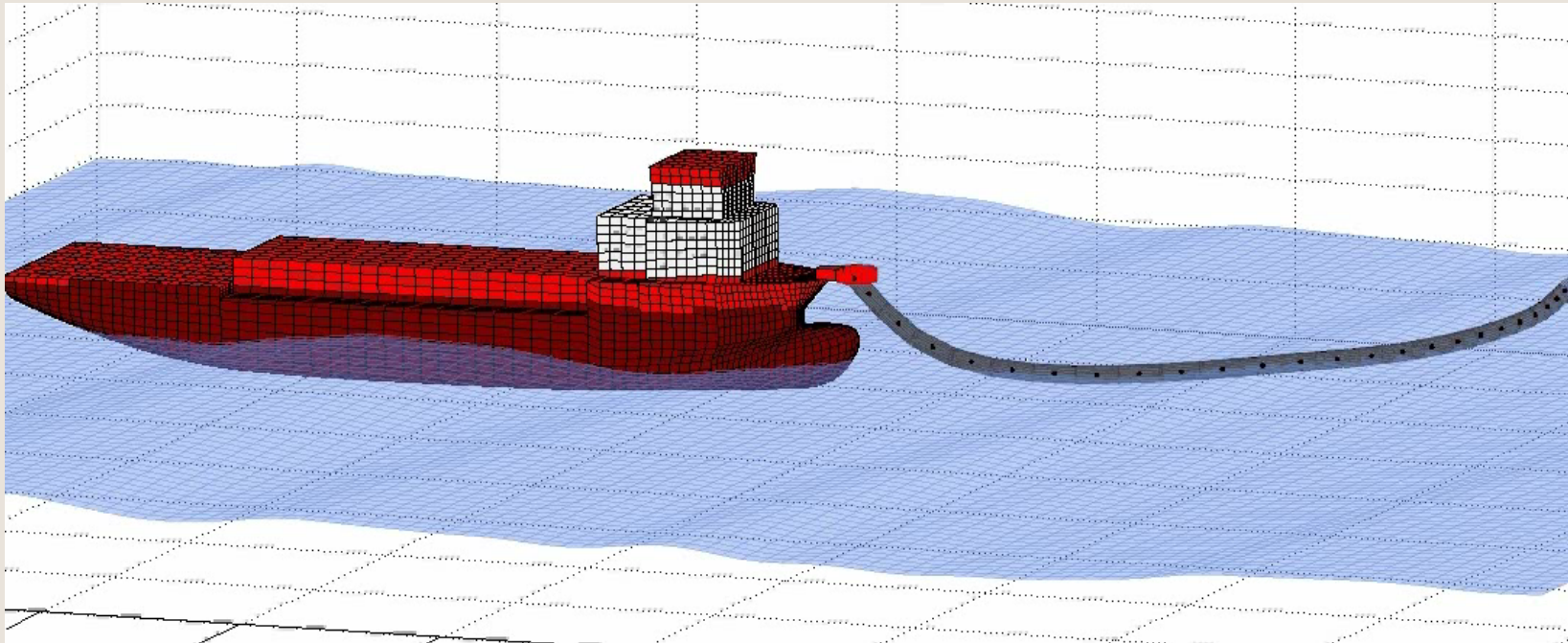
Loaded ship, 35 degree pipe angle, 240 degree wave angle

		Tp(s)							
		4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5
Hs(m)	0.5	Workable	Workable	Workable	Workable	Workable	Workable	Workable	Workable
	1	Workable	Workable	Workable	Workable	Workable	Workable	Workable	Workable
	1.5	Workable	Workable	Workable	Workable	1	1	1.1	1.3
	2	Workable	Workable	Workable	1	1.4	1.4	1.5	1.7
	2.5	Workable	Workable	Workable	1.3	1.7	1.7	1.9	2.2
	3	Workable	Workable	Workable	1.5	2.1	2.1	2.3	2.6
	3.5	Workable	Workable	Workable	1.8	2.4	2.4	Not workable	Not workable
	4	Workable	Workable	1.1	2	2.7	Not workable	Not workable	Not workable
	4.5	Workable	Workable	1.3	2.3	Not workable	Not workable	Not workable	Not workable
5	Workable	Workable	1.4	2.5	Not workable	Not workable	Not workable	Not workable	

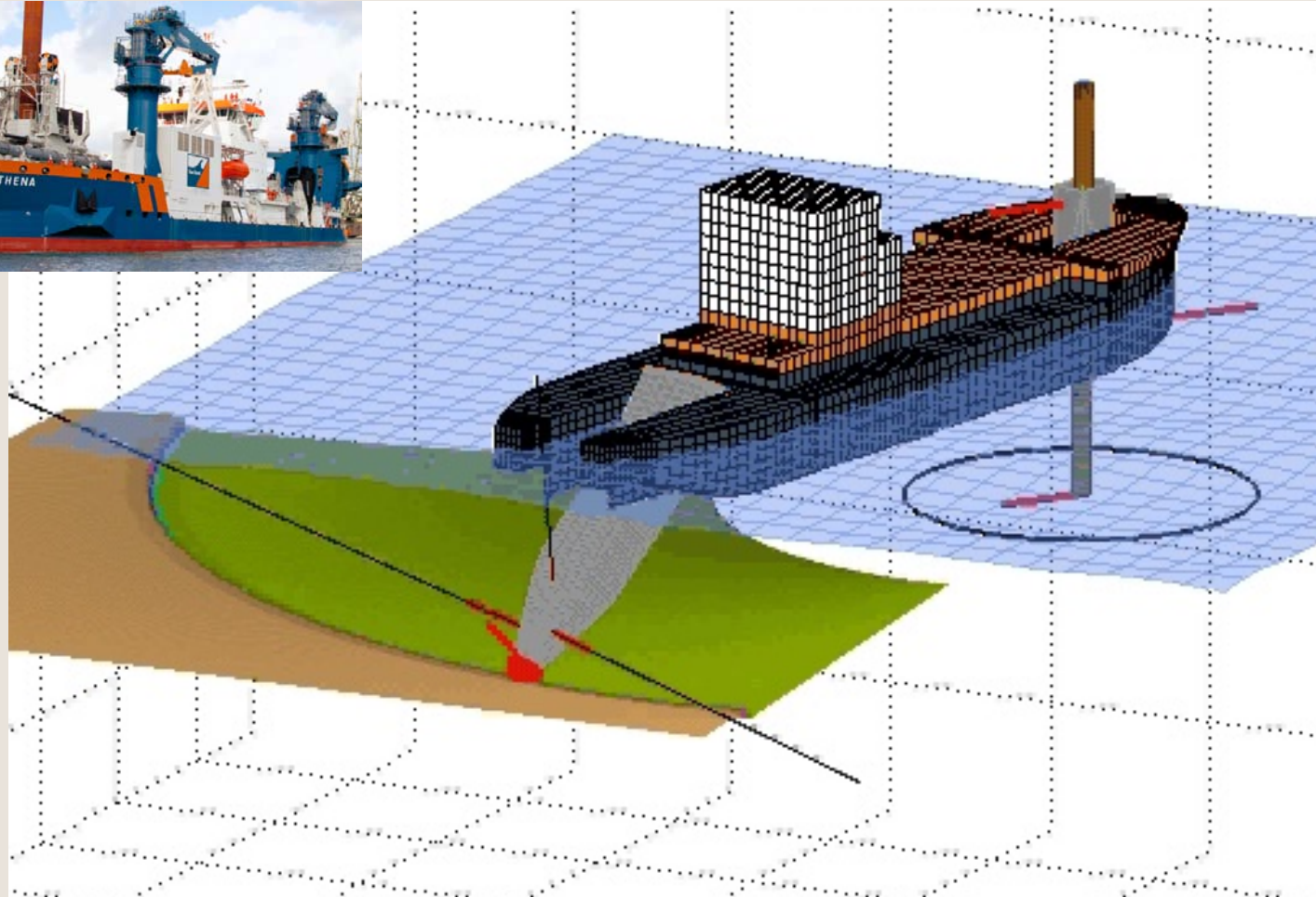
Workability table
(blue is workable,
red is not workable)

Simulation model

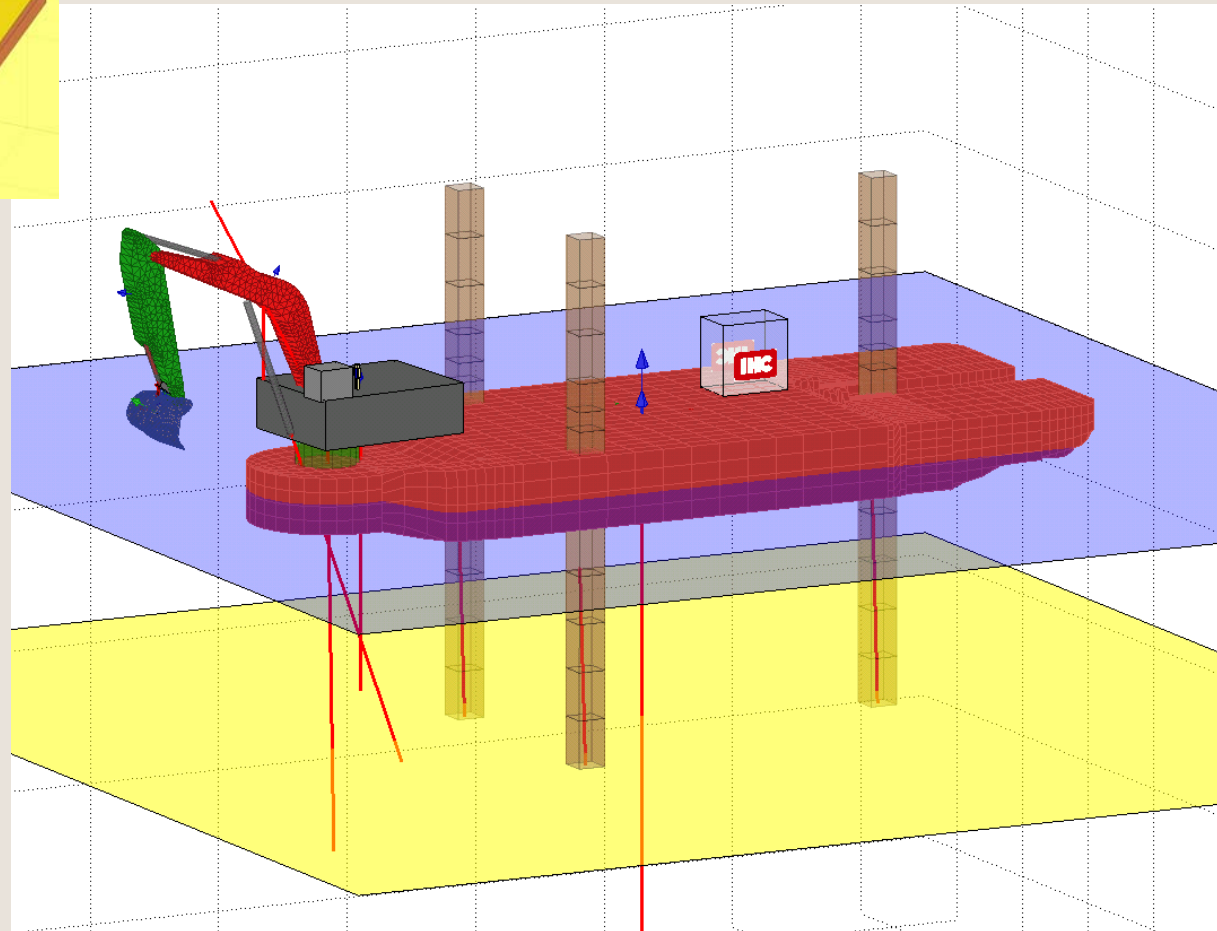
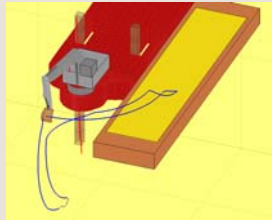




DODO for cutter dredges



DODO for backhoe dredges



Efficient dredge components allowing optimum productivity.

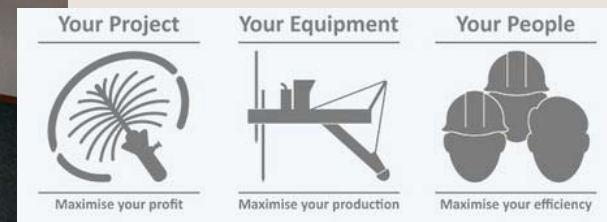


Another way; emission reduction by Project, People and use of Equipment

Project planning; if possible, consider seasonable wind, wave and current aspects,

People; uniform knowledge and approach of low emission tactics for shore support and dredge crew,

Training; simulate and train crew on regular basis.



Conclusions

- We have enormous challenges ahead.
- New EPA and IMO regulations must be considered positively and as first steps towards a cleaner environment.
- We have to be critical on isolating specific emission regulations and consider the system perspective (Life Cycle impact Assessment).
- We have to focus on emission per yd³ dredged material instead of emission per installed kW.
- We have direct our joined forces into making creative combinations of emission reducing techniques and systems, innovative and efficient equipment, lean and mean dredge crew and project approach. This will result in remarkable results with lowest environmental impact possible.
- We continuously have to improve collaboration (Governments, Contractors, OEM Industries, equipment suppliers and Universities) to strive to a balanced legislation

Questions?

