A novel approach for holistic environmental assessment of ships

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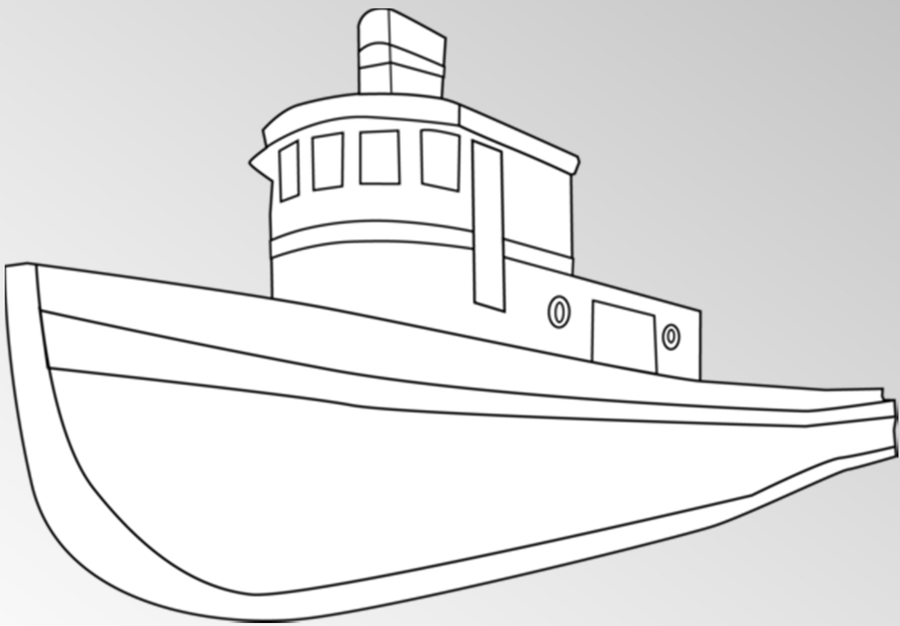
Presentation Summary

- Research background
- Aim and objectives
- Method overview
- Method analysis
- Results
- Discussion & Conclusions



Research background

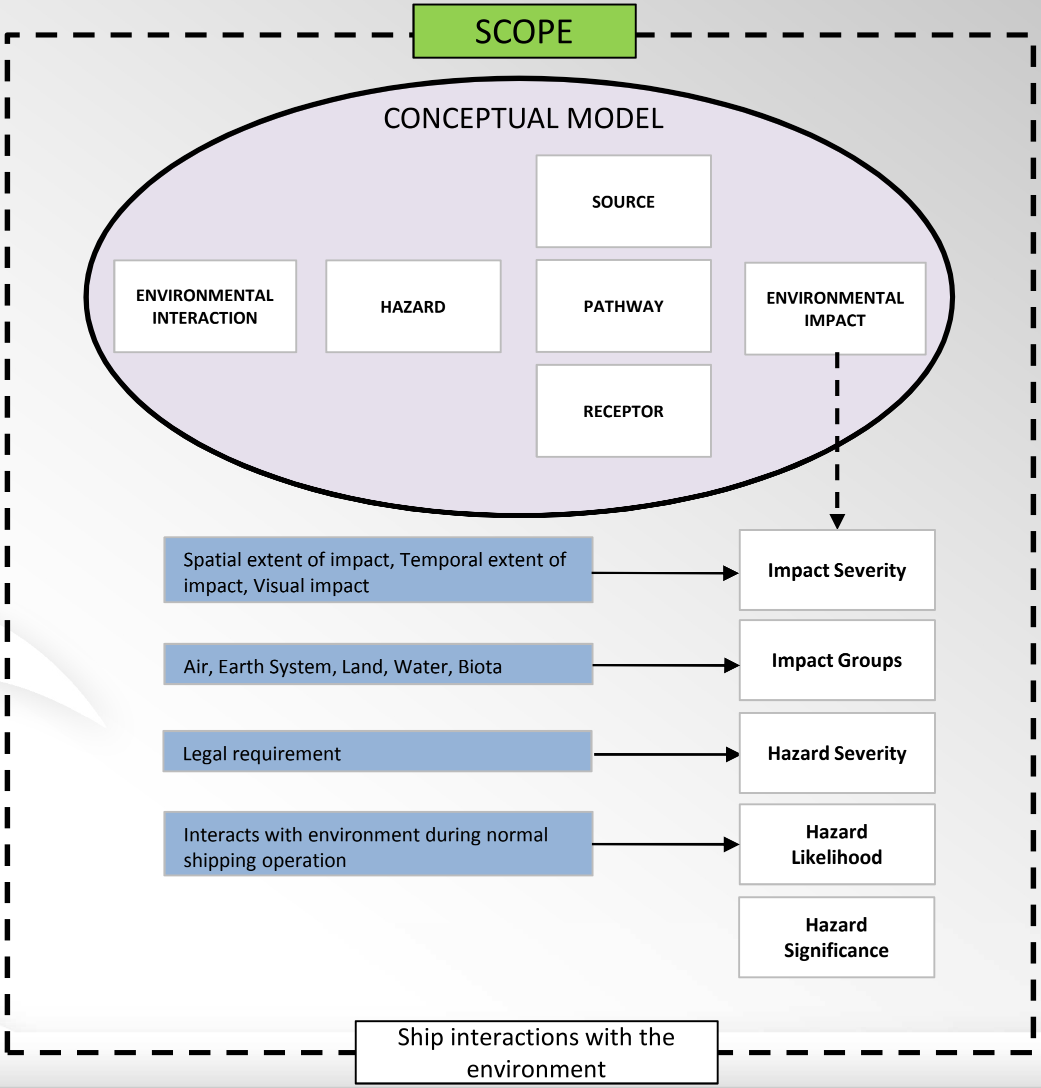
- Analysis of existing environmental initiatives in shipping
  - Categorisation
  - Identification of Indices
  - Formulation:
    - Indicators
    - Weightings
    - Scoring range
- Limitations with existing indices identified
  - Applicability to ship type/location
  - Not ship specific
  - Rationale of scoring methods unclear
  - Indicator bias
  - Lack of ambition
  - Narrow scope
- Alternative framework based on ship specific impacts proposed

Aim and Objectives

Development of a framework and methodology for assessing the environmental impacts of ships using a holistic approach

- Proposal of framework for ship environmental impact assessment
- Develop methodology for scoring impacts and prioritising environmental hazards
- Identify key environmental hazards and interactions
- Prioritise environmental hazards using proposed method

Framework


SCOPE
CONCEPTUAL MODEL
SOURCE
ENVIRONMENTAL INTERACTION
HAZARD
PATHWAY
ENVIRONMENTAL IMPACT
RECEPTOR
Spatial extent of impact, Temporal extent of impact, Visual impact
Impact Severity
Air, Earth System, Land, Water, Biota
Impact Groups
Legal requirement
Hazard Severity
Interacts with environment during normal shipping operation
Hazard Likelihood
Hazard Significance
Ship interactions with the environment

Method overview

- Identify key **INTERACTIONS** of shipping with the environment using current literature *(Andersson et al., 2016; IMO and the Environment, 2011; Talley, 2003)*
- Identify environmental **HAZARDS**
- Conduct **Source-Pathway-Receptor** analysis to identify **IMPACTS**
- Assess **SEVERITY** of impacts
- Combine impacts into **IMPACT GROUPS**
- Assess Severity of **HAZARDS**
- Determine **LIKELIHOOD** of Hazards
- Calculate significance of **HAZARDS**
- **PRIORITISE** Hazards

Environmental interactions and hazards

INTERACTION	HAZARD
Discharges to sea	Oil
	Sewage
	Grey water
	Antifouling paint
	Invasive species transfer
	Marine litter
Emissions to air	GHG's (CO_2, Methane, N_2O, Halocarbons)
	SO_X
	NO_X
	Particulate
	VOC's
Anthropogenic Noise	Underwater noise
	Noise in port areas
Land	Waste (disposal)
	Resource depletion
Physical	Collisions with large aquatic life

References: (Andersson et al., 2016; IMO and the Environment, 2011; Talley, 2003)

Source-Pathway-Receptor example

ENVIRONMENTAL INTERACTION	HAZARD	SOURCE	PATHWAY	RECEPTOR	IMPACT
Emission to Air	CO_2	Fuel	Combustion	Atmosphere	Climate change Ocean acidification Disruption to carbon cycle
	Methane	LNG Fuel	Slippage due to incomplete combustion	Atmosphere	Climate change
	Nitrous oxide	Fuel	Combustion at low temp	Atmosphere	Climate change
	Halocarbons	Refrigerants	Leakage	Atmosphere	Climate change Ozone depletion
	SO_X	Fuel	Combustion	Atmosphere	Negative radiative forcing Acid rain Dry deposition
	NO_X	Fuel	Combustion (high temperature & low RPM)	Atmosphere	Marine eutrophication Ocean acidification Acid rain Low level ozone Secondary particulate formation Negative radiative forcing
	Particulate	Fuel; oil; components	Combustion; material wear	Atmosphere	Human inhalation (respiratory; lungs, heart) Negative radiative forcing Positive radiative forcing Cloud formation Decrease snow/ice albedo Acid rain
	VOC's	Crude oil; solvents	Evaporation; burning of marine fuel	Atmosphere	Human health - carcinogen Climate change Low level ozone

Impact and Hazard Severity

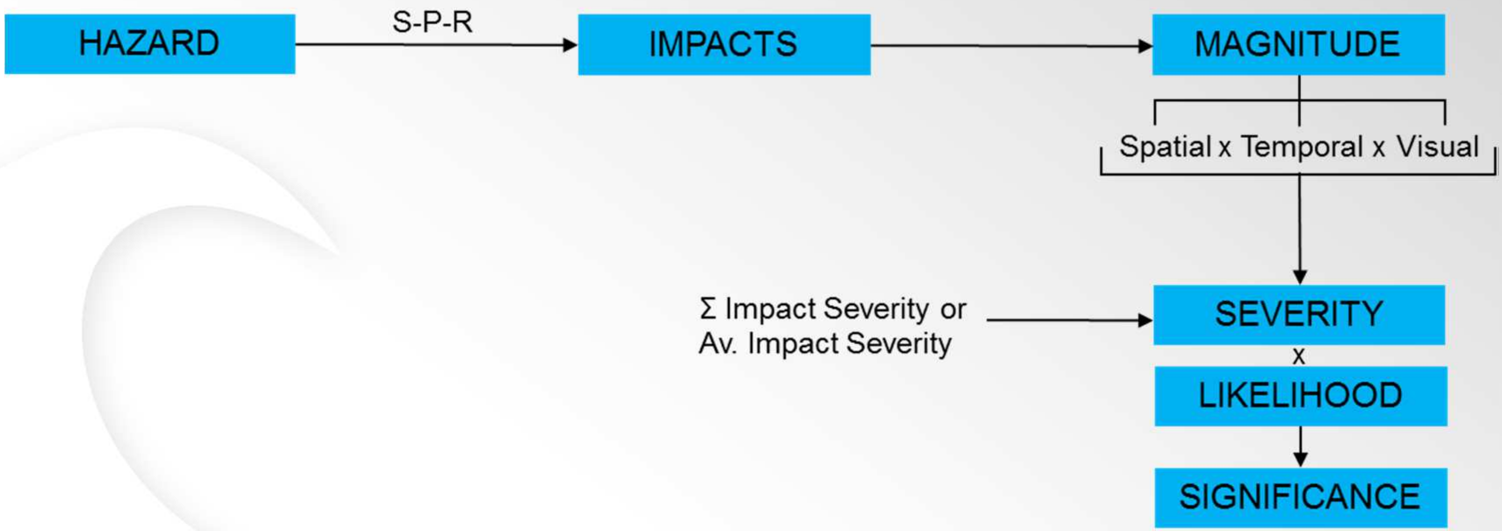
SEVERITY DEFINITIONS (to determine impact magnitude)		
Spatial extent	Global	Impacts the global environment e.g. a change in global atmospheric conditions
	Regional	Impacts the environment at a continental and/or national level
	Local	Impacts on the environment at a port or bay level
	Individual	Impacts which effect individual structures or organisms
	Negligible	No spatial impact on the environment
Temporal extent	Permanent	An impact with permanent or near permanent effects (i.e. > 100 years)
	Temporary	An impact with temporary effects (i.e. < 100 years)
	Immediate	An impact with immediate effects
	Negligible	An impact with no effects
Visual impact	Yes	Impacts are visible to naked eye
	No	Impacts cannot be seen
Legal requirement	Mandatory International	Hazard is covered by IMO mandatory international legislation
	International (not in force)	Hazard covered by IMO international legislation that has yet to enter force legally
	Optional International	Hazard is covered by IMO legislation classified as optional
	Regional	Hazard is not covered by IMO legislation but is covered by national or regional legislation (e.g. EU)
	No legislation	Hazard is not covered by legislation

Impact severity indicators

	IMPACT SEVERITY			HAZARD SEVERITY
IMPACT LEVEL	**Spatial extent**	**Temporal extent**	**Visual impact**	**Legal Requirement**
5	Global	Permanent		Mandatory International
4	Regional			International (not in force)
3	Local	Temporary	Yes	Optional international
2	Individual			Regional
1	Negligible	Negligible	No	No legislation

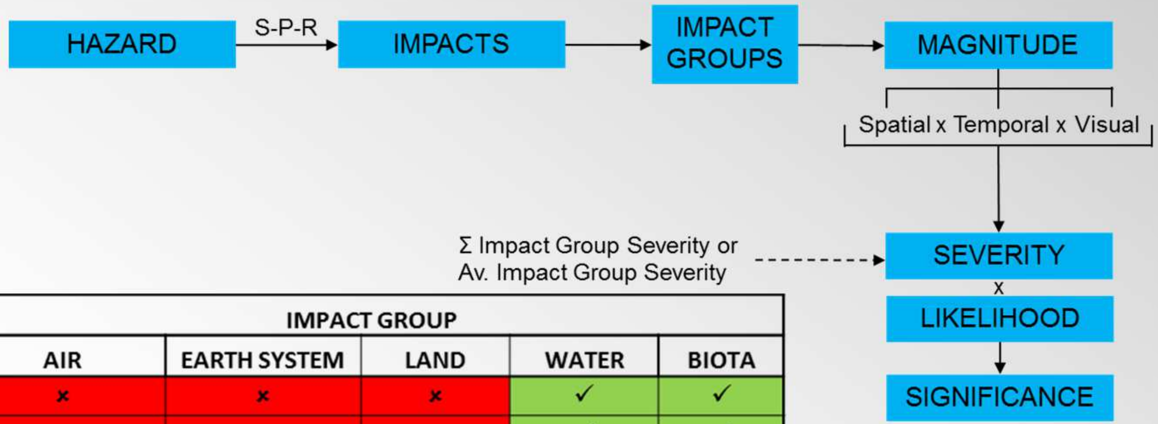
Method 1 – Individual impacts

HAZARD	IMPACTS	IMPACT MAGNITUDE						IMPACT SEVERITY	TOTAL SEVERITY	AVERAGE SEVERITY
		SPATIAL	Score	TEMPORAL	Score	VISUAL	Score			
NO_X	Eutrophication	Regional	4	Temporary	3	No	1	12	84	14
	Ocean acidification	Regional	4	Temporary	3	No	1	12		
	Acid rain formation	Local	3	Temporary	3	Yes	3	27		
	Low level ozone formation	Local	3	Temporary	3	No	1	9		
	Secondary particulate formation	Regional	4	Temporary	3	No	1	12		
	Negative radiative forcing (cooling)	Regional	4	Temporary	3	No	1	12		



Method 2 – Impact Groups

HAZARD	IMPACT GROUP	IMPACT MAGNITUDE PER HAZARD						IMPACT GROUP SEVERITY	TOTAL SEVERITY	AVERAGE SEVERITY
		SPATIAL	Score	TEMPORAL	Score	VISUAL	Score			
NO_x	AIR	Regional	4	Temporary	3	No	1	12	123	24.6
	EARTH SYSTEM	Regional	4	Temporary	3	No	1	12		
	LAND	Local	3	Temporary	3	Yes	3	27		
	WATER	Regional	4	Temporary	3	No	1	12		
	BIOTA	Regional	4	Permanent	5	Yes	3	60		



HAZARD	IMPACTS	IMPACT GROUP				
		AIR	EARTH SYSTEM	LAND	WATER	BIOTA
NO_x	Eutrophication	×	×	×	✓	✓
	Ocean acidification	×	×	×	✓	✓
	Acid rain formation	✓	×	✓	✓	✓
	Low level ozone formation	✓	×	×	×	×
	Secondary particulate formation	✓	×	×	×	×
	Negative radiative forcing (cooling)	✓	✓	×	×	×

Method Comparison

METHOD 1

HAZARD	IMPACTS	IMPACT SEVERITY	TOTAL SEVERITY	AVERAGE SEVERITY
NO_X	Eutrophication	12	84 2	14 3
	Ocean acidification	12		
	Acid rain formation	27		
	Low level ozone formation	9		
	Secondary particulate formation	12		
	Negative radiative forcing (cooling)	12		
CO_2	Climate change	75	112 1	37.33 2
	Ocean acidification	12		
	Disruption to carbon cycle	25		
Methane	Climate change	75	75 3	75 1

METHOD 2

HAZARD	IMPACT GROUP	IMPACT GROUP SEVERITY	TOTAL SEVERITY	AVERAGE SEVERITY
NO_X	AIR	12	123 2	24.6 2
	EARTH SYSTEM	12		
	LAND	27		
	WATER	12		
	BIOTA	60		
CO_2	AIR	9	139 1	27.8 1
	EARTH SYSTEM	25		
	LAND	60		
	WATER	25		
	BIOTA	20		
Methane	AIR	9	114 3	22.8 3
	EARTH SYSTEM	25		
	LAND	60		
	WATER	0		
	BIOTA	20		

Method 1 vs Method 2

METHOD 1	METHOD 2
Total severity high if there are a large number of individual impacts, but average severity can be low.	Use of impact groups minimises 'double counting' of impact severity scores
High scoring impacts may be skewed if other impacts are low scoring.	Total severity represented by the amalgamated impact of a hazard on various aspects (impact groups) of the environment
Impact severity can be 'double counted' where multiple impacts have same/similar impact on the environment	Average severity is not skewed by large number of individual impacts

Method 2 more suitable for representing overall impact of hazards on the environment

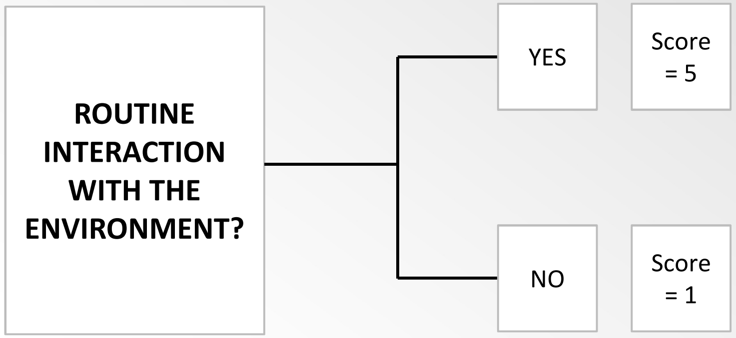
Method 2 - Calculations

Impact group severity = spatial x temporal x visual

Hazard severity = (Σ impact group severity) x legal requirement

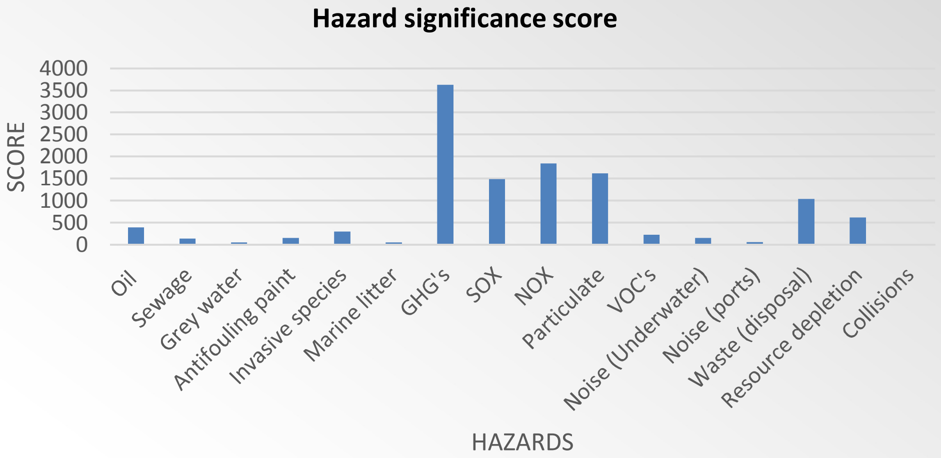
Hazard significance = hazard severity x likelihood

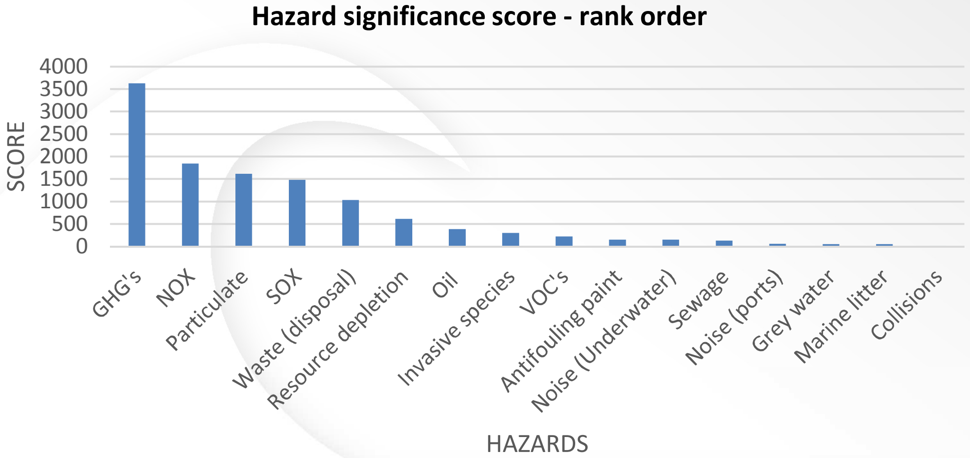
Likelihood of causal event



				LIKELIHOOD	
HAZARD	SOURCE	PATHWAY	RECEPTOR	ROUTINE INTERACTION WITH THE ENVIRONMENT	Score
CO_2	Fuel	Combustion	Atmosphere	Yes	5
Methane	LNG Fuel	Slippage due to incomplete combustion	Atmosphere	Yes	5
Nitrous oxide	Fuel	Combustion at low temp	Atmosphere	Yes	5
Halocarbons	Refrigerants	leakage	Atmosphere	No	1

Prioritising hazards - results





Discharges to sea
Emissions to air
Anthropogenic Noise
Land
Physical

HAZARD	SCORE	RANKING
GHG's	3625	1
NO_x	1845	2
Particulate	1620	3
SO_x	1485	4
Waste (disposal)	1035	5
Resource depletion	615	6
Oil	390	7
Invasive species	300	8
VOC's	222	9
Antifouling paint	150	10
Noise (Underwater)	150	10
Sewage	135	12
Noise (ports)	60	13
Grey water	54	14
Marine litter	54	14
Collisions	16	16

Discussion & Conclusions

- Initial results consistent with industry expectation (LR consultation)
- Further development of numerical indicators required to deliver meaningful rankings
- Development of methodology required for analysis of ‘case study’ vessels

Newcastle University

Thank You

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