A NOVEL APPROACH FOR THE HOLISTIC ENVIRONMENTAL ASSESSMENT OF SHIPS

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ABSTRACT

Shipping has a considerable impact on the environment due to the intentional and accidental release of pollutants. Maritime environmental legislation has tightened in recent years since the introduction of the MARPOL 73/78 regulations, however there is often a significant time gap between when the regulations are adopted and when they legally enter force. The emergence of private voluntary environmental initiatives has occurred in an attempt to bridge this gap, reduce environmental impacts and raise the environmental profile of ships. However, there are inconsistencies in the methodologies used to define ship performance. A critical analysis of existing environmental initiatives in the shipping industry has been conducted, challenging the applicability, scope, environmental ambition and integrity of the methodologies adopted. The analysis highlights significant differences between initiatives with regards to applicability to ship types and locations, assessment rationale and environmental scope. The existing initiatives lack the flexibility to be ship specific and many show bias towards certain environmental indicators, while some lack ambition and have a limited environmental scope. An alternative approach to environmental assessment of ships is proposed which offers a holistic method of assessment which can be applied to multiple vessel types by using a broad, relevant environmental scope based on prioritisation of ship specific environmental impacts. The proposed method adopts a risk assessment based methodology and is intended as a holistic framework for the development of future ship environmental indices. A method and set of criteria for prioritising environmental impacts is proposed.

Keywords: Environmental assessment, Environmental initiatives, Holistic, Environmental impacts of ships

1. INTRODUCTION

There are many independent voluntary environmental initiatives available for use in the shipping sector (Svensson & Andersson, 2011), however there is a lack of coherence regarding how they are used to assess and portray the environmental performance of ships, while the number and diversity of initiatives available for use can cause confusion, hindering progress towards greater sustainability (Lister, 2015). Several well-known initiatives were analysed by Murphy *et al.,* (2013) and further work has highlighted one of the common limitations with current initiatives as a lack of flexibility within the assessment methodologies to evaluate environmental performance based on ship specific impacts. A systematic framework for the identification and assessment of ship specific environmental impacts is outlined, along with a method and set of criteria for numerically scoring impacts to enable ship related environmental hazards to be prioritised.

2. METHODOLOGY

The holistic environmental assessment framework is comprised of several steps as outlined in Figure 1. The first step is the identification of ships interactions with the environment in order to understand which aspects of the environment the ship is likely to impact upon. The second step identifies the environmental hazards associated with a specific ship. The next step consists of a source-pathway-receptor (s-p-r) analysis to determine the possible impacts of the identified ship hazards on the environment. Next, the impacts are assessed using numerical severity indicators (spatial extent, temporal extent, and visual extent) and amalgamated into impact groups to give a severity score for each environmental hazard. An additional severity indicator representing the legal requirements of the hazard is added to give an overall hazard severity score. Hazard significance is then calculated by multiplying hazard severity by likelihood of occurrence. This allows environmental hazards to be prioritised based on the environmental impacts of a specific ship.

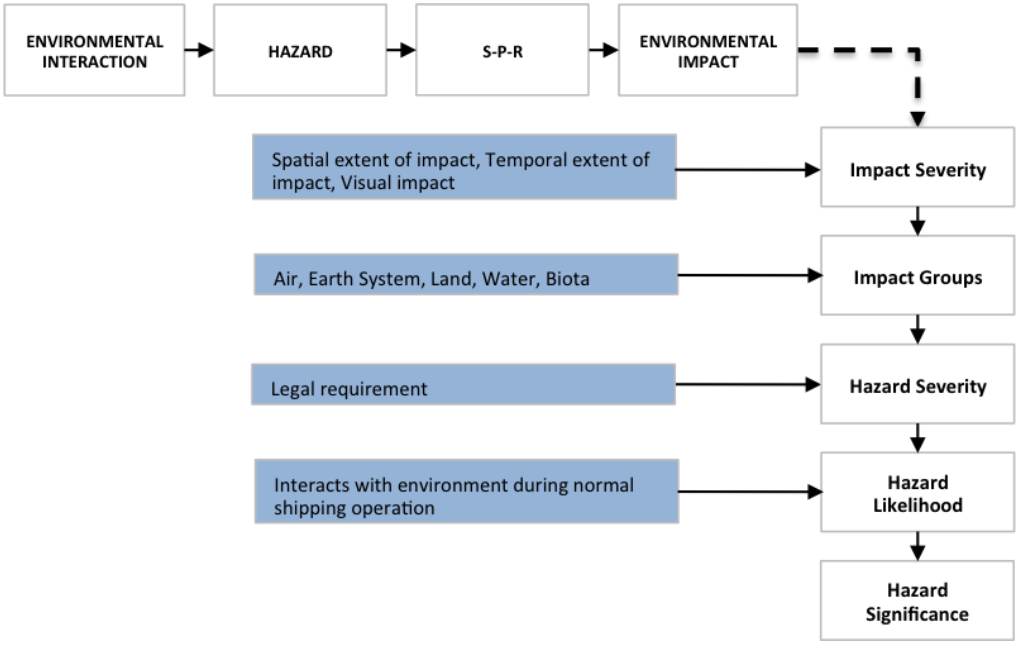

Figure 1: Holistic environmental assessment framework

When an impact has been identified following the s-p-r analysis the severity of the impact is assessed using the indicators outlined in Table 1. Scores are assigned for each indicator and multiplied to give a total score for each impact. Once the individual impacts are amalgamated into impact groups the scores are added together then multiplied by the legal requirement indicator (represents the overall hazard rather than individual impact) to give hazard severity (hs), represented by the equation (a):

$$(a) hs = \sum_{i=1}^{n} IG_n l$$

Where: $IG = s * t * v$

IG = impact groups
s = spatial extent indicator
t = temporal extent indicator
v = visual extent indicator
l = legal requirement indicator
i = number of impact groups

Table 1: Impact and hazard indicator definitions

Indicator			Score	Definition
Impact	**Spatial extent**	Global	5	Impacts the global environment e.g. a change in global atmospheric conditions
		Regional	4	Impacts the environment at a continental and/or national level
		Local	3	Impacts on the environment at a port or city level
		Individual	2	Impacts which effect individual structures or organisms
		Negligible	1	No spatial impact on the environment
	Temporal extent	Permanent	5	An impact with permanent or near permanent effects (i.e. > 100 years)
		Temporary	3	An impact with temporary effects (i.e. < 100 years)
		Immediate	2	An impact with immediate effects
		Negligible	1	An impact with no effects
	Visual impact	Yes	3	Impacts are visible to naked eye
		No	1	Impacts cannot be seen
Hazard	**Legal requirement**	Mandatory	5	Hazard is covered by IMO mandatory international legislation
		International	4	Hazard covered by IMO international legislation that has yet to enter force
		Optional	3	Hazard is covered by IMO legislation classified as optional
		Regional	2	Hazard is not covered by IMO legislation but is covered by national or regional
		No legislation	1	Hazard is not covered by legislation

The resolution of available data is insufficient to accurately predict the likelihood of occurrence of individual impacts, therefore to avoid subjective evaluation likelihood is defined as “yes” or “no” by the occurrence of the hazard routinely interacting with the environment during ‘normal’ operation of the ship. A score (5 for yes, 1 for no) is assigned for likelihood, and multiplied by the hazard severity score attained in the previous step. The resultant score represents the significance of the hazard (HS), represented by equation (b). Scores for hazards

can be compared with one another allowing them to be ranked or prioritised in order of significance with respect to environmental impact.

$$(b)\ HS = hs * L$$

Where:

L = likelihood of hazard

3. RESULTS AND DISCUSSION

An example test run was carried out using estimated indicator scores to show how the framework generates results and prioritises environmental hazards. An example s-p-r analysis was carried out to identify the environmental hazards, and the hazards were assessed using the framework. Figure 2 shows the hazards identified in the s-p-r analysis and the significance scores for each hazard, ranked from highest to lowest score.

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

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
Underwater noise	150	10
Sewage	135	12
Noise in port areas	60	13
Grey water	54	14
Marine litter	54	14
Collisions	16	16

Figure 2: Hazards identified in s-p-r & hazard ranking

The results show that Greenhouse Gas emissions (GHGs) are ranked as the number one environmental hazard in shipping, and hazards associated with emissions to air are the biggest priority. Following a consultation with Lloyds Register these results are generally consistent with initial industry expectation, however it is acknowledged that further development of the numerical indicators is required to deliver meaningful rankings. This study demonstrates the application of the framework methodology.

4. CONCLUSIONS AND FUTURE WORK

Understanding and accurately representing the extent of environmental impact of ships is important in reducing environmental threats. This framework allows ship related environmental hazards to be prioritised based on a ship specific environmental impact assessment methodology. The framework can be integrated into a holistic environmental assessment system for ships to help identify the most environmentally friendly vessels and help identify areas of improvement in ship environmental performance. The next step is to develop the methodology so that it can be tested on some case study vessels, and analyse the results to determine the methods effectiveness in differentiating between individual ships.

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