A NOVEL METHODOLOGY FOR NET ENVIRONMENTAL BENEFIT ANALYSIS (SPILL IMPACT MITIGATION ASSESSMENT)

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ABSTRACT

A key objective for any oil spill response is to minimize the impacts to ecological, socio-economic and cultural resources at risk. To that end, the contingency planners and incident managers have traditionally utilized a formal or informal Net Environmental Benefit Analysis (NEBA) for selecting the most appropriate response option(s) to minimize spill impacts and promote recovery. The processes used to conduct a NEBA have varied considerably between industry operators, though the outcomes in terms of strategy development have been similar. This variation in NEBA approaches can lead to challenges with communicating the underlying basis of response strategies to stakeholders. The oil industry published updated guidance in 2015 to explain the general principles of the NEBA process and facilitate stakeholder involvement. However, with industry's increasing reliance on NEBA to enhance the transparency of response strategy development, a consistent methodology for conducting formal NEBAs was required.

In response to the above issue key industry Associations (API, IOGP and IPIECA) initiated a collaborative project on developing a qualitative NEBA methodology that can be utilized if other, fit-for-purpose NEBA methodologies are not applicable or available. Industry has also begun transitioning to a more representative term for the NEBA process which is Spill

Impact Mitigation Assessment (SIMA). Therefore, the SIMA term is used henceforth but it is important to note that the method described herein is not exclusive to the SIMA term and, as with NEBA, only represents one of many approaches that can be utilized to conduct a SIMA.

This qualitative methodology is designed to give a consistent approach to larger or higher consequence oil spill scenarios, where multiple spill response options are being considered and a formal SIMA is warranted. Several industry spill response specialists and an independent expert participated in this project, resulting in the development of *Guidance on Implementing Spill Impact Mitigation Assessment* (IPIECA-IOGP-API 2017 *in press*).

The SIMA guidance document consists of several components including:

- Use of SIMA in pre-spill planning and spill response
- The SIMA four stage process:
  - Compile and evaluate data
  - Predict outcomes/impacts
  - Balance trade-offs
  - Select best response option(s)
- Guidance on assessing relative impact levels and modification factors associated with each response option
- Example applications of the SIMA methodology

The SIMA methodology is a tool to identify the response option(s) that will best mitigate the overall impacts of an oil spill.

INTRODUCTION

The term Net Environmental Benefit Analysis, and its acronym NEBA, have been used extensively over the years to describe a process utilized by the oil spill response community for guiding the selection of the most appropriate response option(s) to minimize the net impacts of spills on people, the environment and other shared values (NOAA, 1990 and Baker, 1993). IPIECA and IOGP jointly published a Good Practice Guide (GPG) on “Oil spill response strategy development using NEBA” (IPIECA-IOGP, 2015), updating an earlier NEBA publication within the IPIECA Oil Spill Report Series. In the wake of this GPG’s publication, the development team felt that a more detailed ‘how-to’ methodological guideline was also required that would be supported by industry and applicable to a wide range of oil spill scenarios. To that end, IPIECA and IOGP collaborated with API to develop this methodology which is the focus of this paper. Attempts were made to identify both U.S. and international NEBA related regulations to ensure the new methodology was regulatory compliant but none were found.

Concurrently, the oil and gas industry began a debate on the appropriate use of the acronym NEBA. Given that the selection of the most appropriate response action(s) has in practice been guided by more than just environmental (typically interpreted as ecological) considerations, the industry is seeking to transition to a term that better reflects the process, its objectives, and the suite of shared values which shape the decision-making framework, including ecological, socio-economic and cultural aspects. Industry has consulted directly with non-industry stakeholders who have expressed support for transitioning to a more appropriate term. Industry is thus introducing the term Spill Impact Mitigation Assessment (SIMA) as a replacement for NEBA. It is recognized that the transition from NEBA to SIMA will take some time, but the industry believes it is important to begin the process of more accurately describing this long-standing practice and its objectives. For the purposes of this paper, all references to SIMA should be understood to mean NEBA in its broader context.

Protecting the health, safety and welfare of responders and the local community underpins the consideration of all response activities. Operations should have due regard to safety of responders in carrying out deployments and the potential exposure to both response personnel and the wider public to spilled oil and associated vapours. There are situations where the safety benefits or concerns associated with a response option may become the dominant driver of strategy development. If a response option could not be safely undertaken in the context of a scenario, it would not be considered feasible and therefore excluded from that scenario's SIMA. Otherwise, safety is not directly considered in a SIMA.

Given the broad range and scale of oil spill planning scenarios, diverse perceptions of the value of ecological, socio-economic and cultural sensitivities and the innate realities of oil spill response field operations, there is no single SIMA methodology which is suitable, or indeed appropriate, for application in all situations. The SIMA process developed by IPIECA, IOGP and API and described herein can be applied to a wide range of scenarios and situations but is primarily applicable to larger or higher consequence oil spill incidents or scenarios where multiple spill response options are being considered. For smaller, lower consequence spills where only one or two response options are contemplated or feasible, a formal SIMA, regardless of the method used, is generally not warranted. Additionally, in actual incidents where response strategy decisions must be made under time-constraints, an abbreviated version of this SIMA process may be required that relies primarily or solely on the best available professional judgement/expert opinion.

SIMA PROCESS SUMMARY

The conceptual process adopted by this SIMA methodology as well as the aforementioned NEBA GPG (IPIECA-IOGP, 2015) involves four stages:

1. **Compile and evaluate data** for relevant oil spill scenarios including fate and trajectory modelling, identification of resources at risk and determination of safe and feasible response options.
2. **Predict outcomes/impacts** for the "No Intervention" (or "natural attenuation") option as well as the effectiveness (i.e. relative mitigation potential) of the feasible response options for each scenario.
3. **Balance trade-offs** by weighing and comparing the range of benefits and drawbacks associated with each feasible response option, compared to No Intervention, for each scenario.
4. **Select the best response option(s)** to form the strategy for each scenario, based on which combination of techniques will minimize the overall ecological, socio-economic and cultural impacts and promote rapid recovery.

The version of SIMA described herein does not quantify the potential impacts of an oil spill. Rather, it assesses the relative impact mitigation potential of candidate response options, to choose and prioritize those that will most effectively minimize the overall consequences of a spill.

This methodology focuses primarily on the Predict Outcomes and Balance Trade-offs stages of a SIMA, as they are generally the most complex and are often emotive within the wider community. The latter may be due to misunderstandings about response options' effectiveness and potential drawbacks. There may also be differing or conflicting stakeholder opinions of the relative value of ecological, socio-economic or cultural resources at risk. Consequently, this SIMA methodology provides a transparent framework to consider and balance the consequential trade-offs of using the feasible response options - recognizing their potential benefits, limitations and drawbacks - compared to No Intervention.

WHEN SIMA MIGHT BE USED

Pre-spill contingency planning

When SIMA is used during the contingency planning process, it provides an unhurried, consensus-based approach incorporating dialogue with relevant stakeholders. SIMA conducted during contingency planning not only develops the most effective response strategy for each planning scenario; it also helps determine the subsequent provisioning of suitable response equipment and supporting logistics within a tiered preparedness and response framework (IPIECA-IOGP, 2014a). This SIMA methodology brings transparency and credibility by documenting and demonstrating how potential response options have been analysed and incorporated into strategy development. The SIMA can also be a useful tool to incorporate in the preparation and conduct of oil spill simulation exercises.

Incident response

For responses to incidents where a scenario was covered by contingency plans that incorporated SIMA, the following process can be used:

- Select the planning scenario that most closely matches the incident circumstances, along with its associated SIMA-derived response strategy, as a starting point.

- Validate or adjust as needed the assumptions and considerations used in the planning SIMA to account for actual incident conditions; there can be a dynamic use of SIMA throughout the response.
- Confirm the applicability of the pre-determined response strategy or adjust as necessary.

For incidents where the spill parameters are too dissimilar from those used in the planning SIMA or where a planning SIMA has not been conducted, an abbreviated version of the process outlined in this document can be followed. This will avoid delays in implementing a response that may result in greater impacts. This will generally involve reduced reliance on stakeholder consultation and empirical data. There will be with a greater reliance on expert opinion and professional judgement, while still maintaining the underlying SIMA principles.

WHO IS INVOLVED IN THE SIMA?

SIMAs present the opportunity, within limits depending on the context, to build consensus-based response strategy amongst industry, government authorities and key stakeholders from the wider community. The personnel who may be actively involved in a SIMA, or be consultees, will vary greatly depending on the spill scenario circumstances and locality.

Where SIMAs are undertaken in support of contingency plans, there are likely to be a variety of subject matter experts engaged in the process (e.g. modellers, environmental and other specialists and experienced responders) alongside possible consultations with potentially affected stakeholder groups (e.g. fishing, tourism and local community) and relevant authority representatives, including regulators and resource trustees (e.g. nature conservation agencies). The specific make-up of the people involved in the dialogue will depend on the spill scenarios, the local setting and the ecological, socio-economic or cultural resources threatened by a possible spill. In the case of abbreviated SIMAs carried out during actual spills, the group of people involved is likely to be streamlined due to time constraints. In such cases the SIMA process will be undertaken through the existing emergency management structure, rather than the contingency planning process.

QUALITATIVE SIMA PROCESS

The four-stage qualitative SIMA methodology developed jointly by IPIECA, IOGP and API is described in greater detail in the following sections to provide a better understanding of how it is applied in the selection of the response option(s) that will result in the least overall impact to resources at risk and promote recovery.

Stage 1: Compile and Evaluate Data

It is fundamental practice within contingency planning to identify a suitable selection of credible accidental oil release scenarios. In accordance with the tiered response approach, planners aim to define a group of scenarios that collectively represent the range of spill risks and response challenges for an asset or operation. Typically, only a worst credible case discharge will be considered in the SIMA, to assure that adequate response capabilities are available across all response tiers. However, smaller event scenarios may also be chosen to refine response strategies and capabilities at lower response tiers. Additionally, for operators with multiple facilities, assets or operations in a relatively small area, a single scenario or set of scenarios may be developed that is representative of all potential sources in the area. Further guidance on oil spill risk assessments has been published by the industry associations (IPIECA-IOGP, 2013).

Once the SIMA scenario(s) is chosen, oil fate and trajectory modelling is typically used to identify the potential geographical area of impact for each chosen scenario. The modelling's input parameters include location, oil type and properties, volume of release, duration of release and the prevailing hydrodynamic and metrological conditions.

For some locations, it may be suitable to consider separately the same release parameters at different times of year or seasons by using deterministic (single run) modelling. Stochastic (probabilistic) modelling can also be used to integrate hydrodynamic and metrological conditions over multiple seasons and years to identify an overall potential geographic area of impact. In the case of incident response SIMAs, deterministic modelling will be required to predict the specific area of impact.

The modelling output(s) is then combined with information on sensitive resources and their locations to identify the ecological, socio-economic and cultural resources most at risk from a planning scenario or actual spill. Resource information is typically found in the literature and may have been consolidated within environmental and social impact assessments (ESIAs) and oil spill sensitivity mapping projects. Input from the local community is generally required to identify their most valued resources.

The potential at-sea response options are typically no intervention (natural attenuation); on-water containment and recovery; sub-sea dispersant injection; surface dispersant application; in-situ (controlled) burning; and shoreline protection (used to exclude or deflect oil from a section of shoreline). These options must be evaluated against each scenario's incident circumstances (oil type, volume, characteristics; prevailing wind and wave conditions, logistical support availability, etc.) to determine their deployment feasibility. All feasible response options are carried forward in the SIMA process. It is emphasized that the at-sea response strategy is likely to comprise a suite of the available options, deployed at different locations and times through the incident. The SIMA assists in prioritizing which options to use where and when. It does not automatically lead to choosing one option to the exclusion of others.

Separate SIMAs may be conducted for shoreline clean-up and protection operations to address specific questions within a scenario, i.e. techniques to use at a specific beach or sensitive area. In these cases, the response options will be amended to reflect suitable shoreline techniques, with the methodology otherwise remaining the same. The SIMA methodology can also be used for freshwater or inland spill scenarios wherein a different set of response options would be evaluated.

Stage 2: Predict Outcomes

This stage lies at the heart of the SIMA methodology. A prediction is made of the outcomes – i.e. relative impacts to resources at risk - for each scenario, using No Intervention as a baseline. The feasible response options are then evaluated, based on the extent to which they have the potential to either mitigate, exacerbate or not alter the No Intervention outcome. A comparative matrix is the key tool used to facilitate the evaluation of candidate response options. It may be beneficial to engage relevant stakeholders in at this stage of the process, though it is more usual to undertake this during the ‘balance tradeoffs’ stage.

Although each response option may individually alter the outcome to varying degrees, no single option is likely to be fully effective. Combinations of different options, utilized in different geographic locations and possibly at different times are usually necessary. However, due to the complexities involved in aggregating the impact mitigation potentials of multiple response options, each option is assessed independently in the matrix.

Fig. 1 provides an illustrative overview of the process of predicting outcomes using the comparative matrix. The steps followed (i to v) to compile the comparative matrix shown in Fig. 1 are explained in subsequent sections. A hypothetical offshore surface oil spill scenario is used to populate the matrix in Fig. 1. As this is a surface release, the use of subsea dispersant is not feasible.

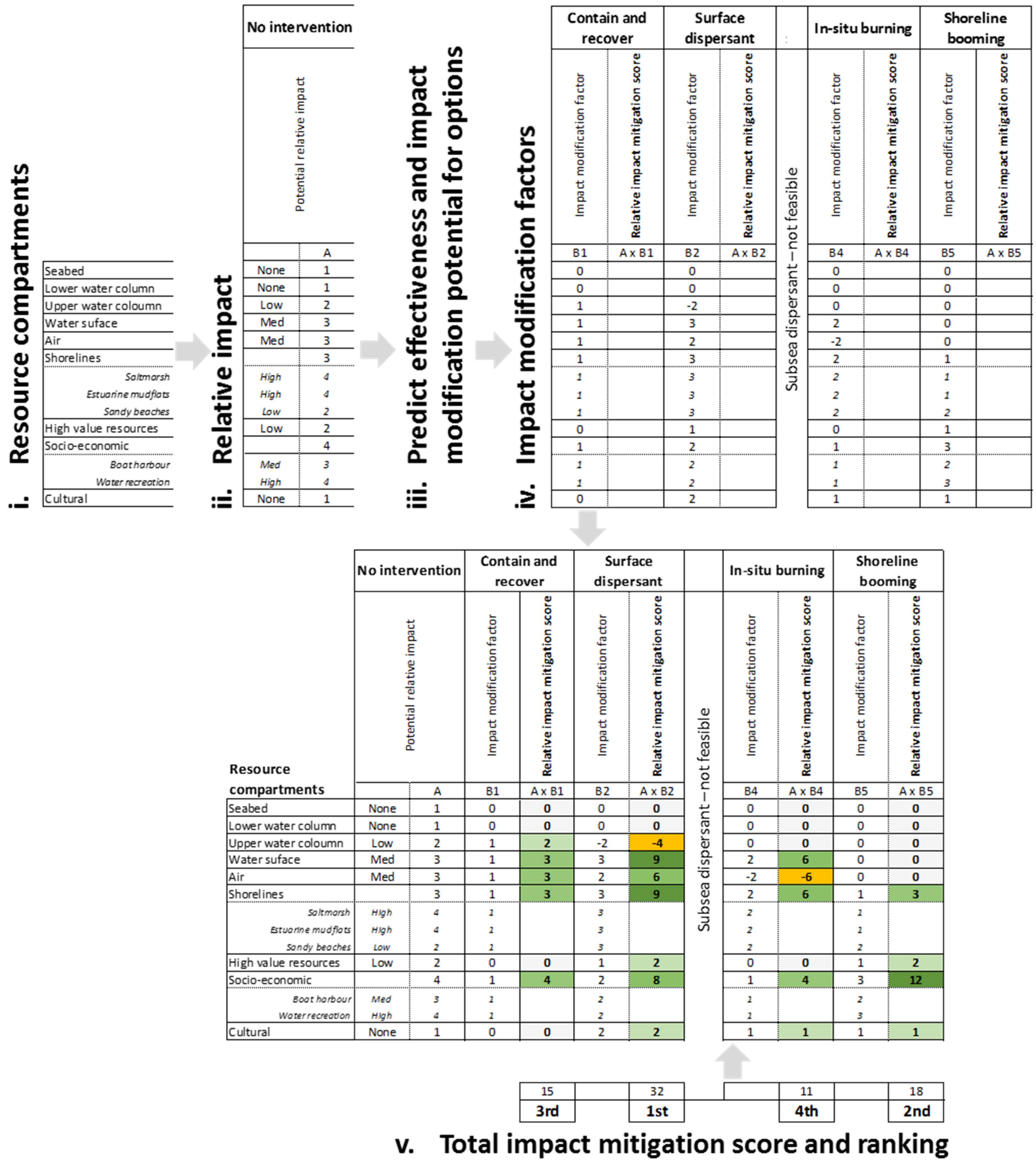

Figure 1 Overview of the Predict Outcomes (i to iii) and Balance Tradeoffs (iv to v) stages

i. Resource compartments

Within the potential impact area identified by the spill trajectory modelling, the existing ecological, socio-economic and cultural resources, i.e. those resources at risk identified in Stage

1, should be segregated into appropriate resource compartments, such as those shown in Fig. 1. Ecological resources are often assessed at the broad habitat level (rather than species level) and socio-economic and cultural resources in similarly broad compartments (for example maritime recreation, commercial fishing and tourism can be combined into the socio-economic category) rather than evaluating each component individually. This is the preferred approach as it generally provides suitable detail for the SIMA outcomes. Complex scenarios could require further breakdown and evaluation of additional compartments.

Specific resources with either particularly high ecological significance (e.g. endangered species, important breeding areas or sites of wildlife aggregations) or representing exceptional socio-economic / cultural value to the affected community, can be combined under the 'high value resources' category to facilitate additional consideration in the matrix. Alternatively, they can be listed as sub-compartments under the high value or their associated general resource category as shown (i.e. additional rows added to the matrix). It is important to note that increasing the complexity of the SIMA by sub-dividing resource compartments can become time-consuming. Analysing resources at greater detail should only be undertaken when it is reliably expected to bring material change to the SIMA's outcome by altering response strategy development.

ii. Relative impact assessment

A base case of relative impact under the No Intervention option is assessed. Each resource compartment (i.e. row in the matrix) in Fig. 1 is allocated a potential impact level based on the expected impacts of the spill scenario if no response actions were undertaken.

For most SIMAs, relative impact levels of 'none to insignificant', 'low', 'medium' and 'high' may be used. Complex scenarios may assign more refined levels (e.g. none, low, medium, high, extreme) or use more quantitative metrics. Additional levels should only be considered where there is a reliable expectation that this refinement will make a material change to strategy development. The guideline document provides additional discussion of how relative impact levels may be assigned.

The relative impact levels are then each allocated a score as shown in Fig. 1. These may be scores of 1, 2, 3 and 4 for none/insignificant, low, medium and high, respectively (column 'A' in the matrix). If there is elevated concern for resources that experience greater impacts, it may be preferred to weight the scores of the higher impact levels, for example increasing the medium and high impacts score to 4 and 6 respectively. If multiple individual resources/sub-compartments are listed under one of the general resource compartments, their relative impact and impact mitigation rankings/scores should be averaged to avoid the total impact mitigation scores being disproportionately biased toward those resources.

iii. Impact modification potential

The feasible response options are now assessed with respect to their potential to mitigate the baseline impacts identified above for the No Intervention option. Based on experience, professional judgement and possibly supplemental modelling, the potential effectiveness of each response option and the degree to which the baseline impacts to each resource compartment will be reduced or exacerbated is predicted. The anticipated effectiveness of each response option is a function of various factors, including the oil type, weathering and spill volume, sea state, encounter rate (i.e. the rate at which a response option can treat spilled oil) and logistical considerations. The guideline document provides further discussion. This step provides the basis for the allocation of *impact modification factors* (see below) for each response option and resource compartment combination during the next stage. In some cases, it may be beneficial to identify preliminary or draft *impact modification factors* as a starting point, prior to engaging with relevant stakeholders to balance trade-offs.

Stage 3: Balance Trade-Offs

iv. Relative impact mitigation score

Building on the considerations under step iii, an *impact modification factor* is used to indicate the degree to which the 'No Intervention' impacts are altered by each response option. If a response option mitigates the impacts to a resource compartment, a positive modification number is entered. Conversely, if the response option exacerbates the impacts or creates a new impact, then a negative number is entered. If the degree of change relative to No Intervention is minor, moderate or major then a positive or negative 1, 2 or 3, is entered (see Table 1). The impact modification factors for each resource (i.e. row) are entered under the 'B' columns (B1, B2, B3 etc.) for the response options.

Impact modification factor	Description
+3	Major mitigation of impact
+2	Moderate mitigation of impact
+1	Minor mitigation of impact
0	No or insignificant alteration of impact
-1	Minor additional impact
-2	Moderate additional impact
-3	Major additional impact

Table 1 Impact modification factors

Using the matrix, the relative impact score (column 'A') for each resource compartment is multiplied by the associated impact modification factor for each response option (Columns B1, B2 etc..) to create a relative impact mitigation score for each resource compartment and response option combination. This score is shown in the columns ('A x B1', 'A x B2' etc.), representing an indication of the relative change that each response option is likely to bring in the base case level of impact to each resource. Since it is derived from a qualitative ranking of impacts, the score should not be taken as a quantitative measure of impact. It is recommended that scores are rounded to whole units.

To provide a visual reference of the potential impact mitigation associated with each response option and emphasize the process is not quantitative, users of the matrix may wish to adopt a colour coding for the relative score of impact mitigation. Fig. 1 uses the colour scheme as defined in Fig. 2. It provides an intuitive scale from major impact mitigation (dark green) through to major impact increase (red).

Range of scores	**Colour**	**Description**
8 to 12		Major mitigation of impact
3 to <8		Moderate mitigation of impact
>0 to <3		Minor mitigation of impact
0		No or insignificant change
>-3 to <0		Minor increase in impact
>-8 to -3		Moderate increase in impact
-12 to -8		Major increase in impact

Figure 2 Colour scheme used to indicate relative impact

v. Total impact mitigation scores

The scores for each response option are summed at the bottom of the relative impact mitigation columns. This total is a qualitative prediction of the degree to which each option mitigates the scenario's overall impact (i.e. compared to No Intervention). The total scores can then be used to rank the relative ability of each response option to mitigate impacts and enhance recovery. This ranking allows objective comparison of the options when balancing trade-offs in the next step. It is important to note that the total scores do not have a direct mathematical relationship (i.e. a score of +20 does not mean an option will achieve twice the mitigation as one scoring +10).

Totals should only be used for comparative purposes within each specific SIMA. Furthermore, the ecologically-based compartments outnumber the single socio-economic and cultural ones in the example given. This skews the total towards ecological concerns. In many scenarios, this may be appropriate but it should be considered when interpreting the matrix to select the best response options.

SIMA aims to mitigate the overall impacts of the spill and this involves balancing the resource impact trade-offs between the various response options. A fundamental principle is that if a response option increases the impact to a resource, it will only be deployed if this impact is more than outweighed by the mitigation of the impacts to other resources.

The impact mitigation scores generated in the previous stage already attempt to objectively incorporate the relative benefits and drawbacks of each option and, as such, should preclude the need to further balance trade-offs. This is particularly true if potentially affected stakeholders' concerns and values were incorporated in the Predict Outcome process. However, diverse or conflicting opinions may arise concerning a multitude of questions surrounding the importance of impacts to differing resources, such as fisheries versus tourism, shorelines versus water column or wildlife versus community recreation. Such opinions or considerations cannot always be explicitly addressed in the Predict Outcomes stage and thus may require additional discussion.

Because these trade-off discussions can be contentious and emotive, it is recommended they be limited to key stakeholders and government authorities that represent the wider community. If required, the trade-offs already incorporated into the comparative matrix can be further explained and new inputs on resource sensitivities or values can be obtained from the participants. This will either validate the outcomes or may lead to re-evaluation and adjustments to the matrix's inputs which could then modify the outcomes.

Pressures can also be felt during both contingency planning and an incident to either undertake or avoid certain response options. Such pressures are likely to be driven by public perceptions and political considerations, rather than technical understanding. Typically, they result in calls for actions that may be unrealistic, such as the excessive use of shoreline protection booms – including in areas not under threat from spilled oil – and an anti-dispersant or anti-burning position that is not based on factual considerations of the ability of these options to mitigate the overall impacts. SIMA is designed to help overcome these perceptions by presenting a transparent case for appropriate and technically valid response options.

<u>Stage 4: Select Best Response Options</u>

Selection process

The finalized comparative matrix is then used to objectively select the best response option(s) to be implemented for each scenario. This generally involves selecting the option or options with the largest impact mitigation scores. In some cases, the choice may be obvious while others may require further dialogue between the involved parties.

Deployment strategy

The proposed deployment of chosen options can be described in various ways. An approach bringing clarity to the tactical optimization and implementation of strategy is the "cone of response", indicating zones ***where*** specific response options are to be used (e.g. at the source, near an offshore release, further from release in open waters, nearshore and shoreline) and ***when*** they are likely to be deployed.

In the example scenario represented by the matrix in Fig. 1, the surface dispersant option receives the highest ranking for mitigation. The response strategy would therefore legitimately consider surface dispersants as the primary response tool. In the cone of response concept, dispersants would be used to treat the spill where the oil is fresh and forms relatively coherent slicks i.e. close to the source to maximize effectiveness and minimize net impacts. The remaining response options would be positioned within the cone to remove oil that may escape dispersant treatment and migrate beyond the dispersant application area. This would include protecting sensitive areas should any remaining oil threaten nearby shorelines. The tactical practicalities of where these other options might be deployed most effectively is addressed by contingency planners or incident managers.

Once a scenario's strategy is defined in space and time, the planning process serves to identify the equipment, trained personnel, logistics and incident management system that will be required to implement the relevant tactics and operations. This is integrated within an incident management system (IPIECA-IOGP, 2014b) and tiered preparedness and response framework to ensure timely and effective capability that is commensurate to the risk and can evolve to meet an incident's needs.

Regulatory issues

The default case is that all feasible response options should be evaluated to ensure the best option(s) is selected for implementation. However, in the unusual case that a jurisdiction has unequivocally ruled out a response option through its regulations, then it should be excluded from the SIMA process. Where clear regulation does not exist for all response options, it is recommended that engagement with regulators ensues. This engagement would not only promote the best response options for a given operation but also the development of suitable regulation. Thus, the SIMA process can become a driver of an improved legislative framework for future oil spill preparedness.

CONCLUSIONS

The Spill Impact Mitigation Assessment is a qualitative methodology that considers ecological, socio-economic and cultural concerns in support of oil spill response strategy development. The method assesses the potential impacts of a selected scenario to key resources and the ability of feasible response options to mitigate the overall impact of a spill. It is a transparent process and allows inputs from relevant stakeholders. The term, Spill Impact Mitigation Assessment (SIMA), is intended to replace the previously used Net Environmental Benefit Analysis (NEBA) since it is more representative of the process. The methodology described herein is, however, only one of many options that can be used to conduct SIMAs/NEBAs.

A SIMA guideline is in production by industry Associations and is scheduled to be published in 2017. The methodology was tested at a half-day workshop held in Tampa, Florida during November 2016. The 20 participants at this workshop included representatives from USA resource trustees, agencies and the oil industry. The outcome of the test was broad acceptance that the method was useful and aligned to current NEBA practice. Minor modifications were made to the process in the light of comments received. Similar efforts are planned to obtain feedback on the method from relevant international stakeholders to better ensure global acceptance.

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