DELIVERABLE 5.2.
RECOMMENDATIONS FOR JOINT IMPLEMENTATION

rages
risk-based approaches to good environmental status

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Contents

RAGES PROJECT: AIMS AND ACTIVITIES

The Risk-based Approaches to Good Environmental Status (RAGES) project sought to develop, test and apply a standardized Risk-Based Approach (RBA) to assess the Good Environmental Status (GES) for application to the implementation of the Marine Strategy Framework Directive (MSFD). In particular, the project is focused on developing a RBA that could be applied to improve the coordination of the MSFD implementation at sub-regional/regional scales. The project involved the competent authorities from four European Union (EU) Member States (MSs) of the North East Atlantic (NEA), Ireland, Portugal, Spain, and France. All four participating countries have large marine territories, resulting in increased challenges to the effective monitoring and assessment of the GES. In recognition of the challenge posed by the implementation of the MSFD over such large spatial scales, the provision for a RBA (European Commission, 2017a) was incorporated into it to "enable Member States to focus their efforts on the main anthropogenic pressures affecting their waters". The RBA may also serve to enable improved coherence in the implementation across MSs, by providing a robust method that can be applied consistently and it may also improve regional cooperation.

Building on existing and emerging best practices for risk-based management, RAGES Deliverables 2.1 and 2.3 reviewed the state of the art to develop the basis for the application of the RBA within the project, identifying the major steps in the process and techniques that can be applied at each of these steps, following the ISO standard risk management approach. Deliverable 2.2 applied a governance analysis to identify areas in the governance structure which could be adapted to better support sub-regional/regional implementation and harmonization of the MSFD. The general methodology designed in Deliverables 2.1 and Deliverable 2.3 was then tested by application to two pressure-based descriptors, Descriptor 2 (D2) Non-Indigenous Species (NIS) and Descriptor 11 (D11) Underwater Noise. Descriptions of the application of the RBA to these descriptors and recommendations arising from these applications can be found in a series of project deliverables. Deliverables 3.1-3.5 describe the work and provide recommendations based on the application of the methodology to NIS while Deliverables 4.1-4.6 describe the work and recommendations from the application of the methodology to Underwater noise. Deliverable 5.1 of the project provides a standard operating procedure for implementation of the RBA. All the project deliverables can be found on the project legacy website (www.msfd.eu/rages).

This document first briefly summarizes the RAGES RBA, then provides an overview of the general findings based on the application of the methodology to the two descriptors, identifying common advantages, as well as common issues, in the application of the methodology. The final section provides recommendations identifying potential solutions to some common problems in terms of data and expert-judgement approaches. Recommendations are made for developing governance structures that could facilitate the uptake of risk-based approaches at the level of the MSFD common implementation strategy and some general and specific recommendations are made to effectively embed RBA for enhanced regional cooperation, including the potential terms of reference for a Task Group on RBA.

THE RAGES RISK-BASED APPROACH

The risk-based methodology developed by RAGES sets out a common framework for assessment across which the European Commission can fairly assess efforts made in achieving GES for the MSFD. The project took a harmonized approach underpinned by the structure of the ISO standards, and identified synergies between these standards, the risk approach advocated by the MSFD and the elements of the DAPSI(W)R(M) (Elliott et al. 2017). The RAGES RBA is described in detail in Deliverable 2.3 (RAGES, 2021) and summarized in Figure 1. The process was applied in the frame of the project to two descriptors, D2 Non-indigenous species with a focus on criterion D2C1 (number of newly introduced NIS) and D11 Underwater Noise, with a focus on criterion D11C2 (continuous noise). These two pressure descriptors were selected to test the application of the risk-based methodology since both represent areas where there is significant uncertainty regarding the connection between activities, pressures and changes in the environmental state, whilst the nature of the pressures associated with the two descriptors is very different in terms of spatial scale and environmental effects. During the first cycle of the MSFD implementation, aspects of implementation in the NEA were found to be inadequate or partially adequate for both these descriptors (European Commission, 2014 and See Verling et al., 2021a, and Hollatz et al., 2021a for further details). As a result, these descriptors provided both a challenge and an opportunity to apply and test a robust, coherent and defensible RBA under circumstances of limited data and spanning broad geographic areas. These analyses are described in detail in Bartilotti et al (2020a,b,c) and Hollatz et al., (2021a) for D2 and Verling et al (2021b) for D11. The general steps of the RBA as applied to both descriptors was as follows:

Step 1: establishing the context involved the consideration of which aspects of the directive, descriptors, criteria were to be considered, at which scales and using which data sources, proxies and the choice of an analytical approach (which risk-based methodologies were to be used).

Step 2: risk identification involved the assessment of potential pressures and choice of ecosystem elements which were to be assessed. In the case of D2, a compilation of data on NIS in the subregions was conducted and for D11, an initial screening process was carried out.

Step 3: **risk analysis** involved the analysis of likelihood through analysis of exposure of areas or ecosystem elements to pressures. These were carried out by overlapping maps of ecosystem components and pressures (or their proxies) using Geographic Information Systems. Step 3 also involved an analysis of consequence, which was conducted for D11 through expert judgement approaches. For D2, Non-Indigenous Species, the likelihood assessment was based on the identification of high priority NIS for risk assessment (through a Horizon-Scanning approach, combining a structured evidence-based approach using scientific literature and expert judgement), the identification of susceptible areas to NIS introductions (based on their spatial distribution and population status) and on the compilation of hotspots of introduction (based on the shipping densities and distribution of aquaculture facilities). These were combined to estimate which NIS were more likely to be introduced and to identify the areas at higher risk of new NIS introductions. It was not possible to assess consequence for D2, as there was insufficient information on the ecosystem elements (native species and habitats) affected by NIS.

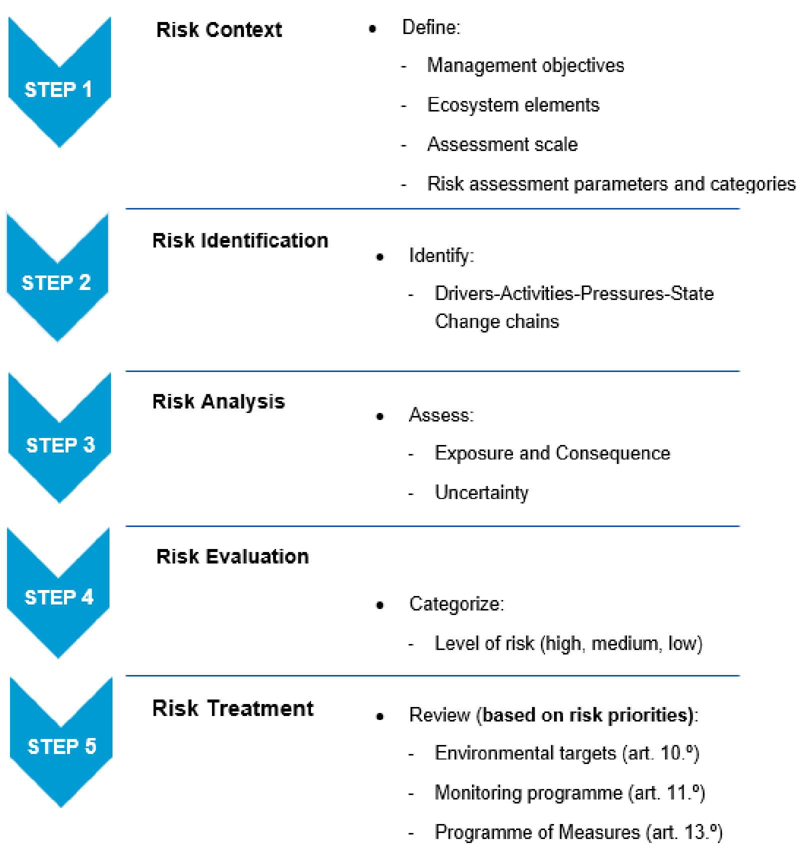

Figure 1. The five steps of the RAGES Risk-Based Approach

For D11 Underwater Noise, likelihood was estimated by spatially overlaying estimated cetacean densities with estimates of noise, using both modelled noise maps and estimates of shipping density (as proxy for shipping noise at the regional scale). These were combined to develop an estimate of exposure for a subset of cetacean species in a range of locations (based on the survey statistical "blocks" from international cetacean survey efforts). For Underwater noise at the regional scale consequence was assessed using an expert judgement approach to identify cetacean species most sensitive to continuous underwater noise.

Step 4: Risk evaluation involved the comparison of different likelihood and consequences of risk to ecosystem elements in different reporting units to identify which elements in which areas were most at risk.

Step 5: Finally risk treatment involved the choice of measure under article 13 of the Directive.

APPLICABILITY OF THE RAGES RBA

In both applications, the ISO framework provided a useful structure to break down the assessment of risk to GES. However, the generic nature of ISO risk steps meant that in both cases considerable care and attention were required to establish exactly how each element of the analysis could be aligned with the generic steps. For example, in Step 1 "Establishing the context" the Directive itself as well as the Commission Decision laying down criteria and methodological Standards for GES (European Commission, 2017a), as well as the revised annex III (European Commission, 2017b) of the Directive, provided considerable context for the analysis, in terms of analytical elements, guidance on Activities and Pressures and ecosystem elements. Beyond these legal documents, several other considerations were also necessary at this stage and these required important analytical choices in terms of data sources, methods to combine and analyse the data, and to estimate levels of confidence. Given the different types of descriptors to be considered in each application, the details of the approaches necessarily varied between the two applications, while the broad steps of the analysis remained the same.

For Risk Identification (Step 2) for NIS, considerable effort was required to compile and harmonise data from a range of sources, including peer reviewed literature, online databases, technical reports and academic theses. This was a time-consuming and laborious task, resulting in a long-list of 454 species in the project study area, gathering NIS from the initial and second assessments up to the end of 2017. Similarly, to develop a priority index of cetacean species and their sensitivity to noise, an expert judgement-based approach had to be developed, the method needed to be tested, validated and applied and relevant experts had to be contacted and be willing to participate.

At the risk analysis stage (Step 3) both applications took a broadly similar approach. The **spatial distribution of likelihood** was assessed through the compilation of relevant GIS data sets. The spatial data on Activities relevant to the two descriptors considered came from a range of sources. A dataset on shipping density freely downloadable from the EMODnet portal (Falco et al., 2018) was used in both applications. The free availability, transparency and easy access of this data enabled broad scale analysis of shipping patterns which underpinned both analyses. For NIS, the shipping density data were used to assess the areas of greatest maritime transport activity, and maps of aquaculture activities were also employed. For continuous underwater noise, at the regional scale shipping density data were employed (as a pressure proxy in the absence of pressure maps for noise at this scale) and at the finer scale modelled data for the spatial distribution of underwater noise were used to assess likelihood of adverse effects. There was considerable debate on the choice and reliability of proxy datasets for noise pressures. While modelled datasets of pressures were considered preferable, detailed analysis also revealed that there was agreement between proxies and modelled datasets in the busiest areas (See Silva et al., 2021), although the noise extended beyond these areas.

For the assessment of **consequences** for D11, an expert judgement approach was developed to rank the sensitivity of cetacean species to continuous underwater noise, based on conservation status, habitats and life stage affected and the severity and sensitivity of a species to acoustic disturbance (physical, perceptual and behavioural). As in the expert judgement approach in the risk-identification step, this process and scoring system had to be designed and tested with experts. For NIS, an assessment of consequence was not possible due to a lack of data on the impact of NIS on habitats and native species. Instead, a Horizon Scanning approach was used to deliver a ranked list of NIS. This exercise considered a range of factors related to the ecology, life-history and adverse impacts of NIS present in the sub-regions Bay of Biscay and Iberian coast, and Macaronesia. Factors relating to the invasion process included the number of introduction pathways, life-cycle duration, reproductive rate, salinity and temperature tolerance, dispersal ability while factors relating to the consequences of arrival included adverse environmental and economic impacts. A scoring system was then developed to enable ranking and crucially, the scoring process was supported by the large dataset assembled on the NIS in the area. Both this and the scoring system developed for D11 allowed for regional approaches to assessment of consequence of pressures and were found to be practicable and broadly acceptable to the experts involved in the development, testing and application. Therefore, they represent a useful first step towards the harmonized implementation of RBA, at least within the scope of regional cooperation in the NEA.

TAKING A HARMONISED APPROACH: BLOCKAGES AND COMMON PROBLEMS

Based on the application of the common risk methodology to the two descriptors we have identified a number of common problems. While our experience relates to the data and information available specifically within the MS that were participants in the RAGES consortium and confined in geographic scope to the NEA, we anticipate that similar problems are likely to present on other regions and for other descriptors.

DATA

Activity data

In contrast to the broadscale shipping density data, regional maps of aquaculture activity (to support application of the methodology to D2) were not freely available at the regional scale. Data regarding the distribution of aquaculture facilities were acquired from different sources. Information for Portugal and Spain was obtained through reports and interactive maps published by the respective Governments. The distribution of the aquaculture facilities in France was retrieved from EMODnet services and contained point information on location only, rather than areal coverage. Shipping density data were also obtained from EMODnet, which provides a freely available processed shipping data for European Waters, broken down to certain ship types. This is a very useful resource, although the under-representation of shipping further from shore is a drawback of the dataset at present and is something that could be improved in the future.

Pressure data

As described above, human Activity data (Shipping density, aquaculture production locations) were used in the absence of true pressure maps in both applications to indicate the spatial distribution of activities and by proxy their resulting pressures. The mapping of sound pressure levels through analysis of ship locations is an area of active research and relies on certain assumptions about the sound pressure levels emanating from different ship types (as well as on a highly complex suite of environmental and physical variables). Ship traffic moves all the time, but generally follows distinct geographic patterns (largely established both through shipping routes and fishing practices). For practical applications, the level of detail and the frequency of assessment of Sound Pressure Levels (SPL) needs to be carefully considered. Harmonizing the shipping type used in the freely available shipping density data set (employed in our analysis) with the shipping categories commonly employed in SPL modelling (Wales and Heitmeyer, 2002; Jansen and De Jong, 2017) could provide a standard basis for the regular modelling of noise at the appropriate temporal and spatial scales for application to MSFD. Similarly, when considering the pressures NIS, the vessel traffic activity information may provide a useful proxy for pressure but a more detailed definition of ship types, shipping routes and ballast water management information could enable further consideration of likely volumes of ballast water discharge in specific locations and more accurate pressure mapping.

State Data

For NIS, despite dedicated project funding, the compilation of the complete subregional species list was a major undertaking. Data reported by individual MS in the first cycle of the MSFD implementation were accessible but did not contain all the relevant information for the RBA. As a result, accessing such data required the exploitation of the professional networks of individuals within the project as well as voluntary cooperation of researchers responsible for D2 reports outside the project. Furthermore, the different methodologies and modalities of recoding data within MS led to further effort in compiling and harmonizing the final data sets. As such, the initial data compilation effort for NIS was a significant and time-consuming aspect of the RBA application, representing a serious inefficiency, since many of these data had already been compiled and reported by MS to the Commission but the resulting information had not been centralized.

Similarly, compilation of the initial cetacean density datasets required re-digitization of published data from reports from across MS. In addition, the compilation of cetacean data required the compilation and harmonization of datasets collected at greatly different spatial scales and also relied on exploitation of professional networks and willingness to exchange data as professional courtesy.

The reporting structures of the MSFD are complicated. The information contained within reports is scattered due to this reporting structure. While recognizing the significant time and effort of MS in the preparation of marine strategies and their associated reports as well as the efforts of the commission in their detailed appraisals of MS reporting (including the useful MSFD online scoreboard), compiling regional information on measures and monitoring is still a major effort. Failure to centralize such data information in a harmonized and easily accessible manner represents a significant inefficiency.

EXPERT JUDGEMENT

The selection of criteria elements and the analysis of likelihood and consequence relied on the development and application of ranking schemes and the application of expert judgement. While the two ranking schemes were tested and accepted by expert groups within their disciplines (NIS and Cetacean biology respectively) sufficient expert time and effort was not available within the scope of the project to rank all species, either for NIS or for cetacean sensitivity. For example, the NIS methodology was only applied to a subset of 188 from a total of 454 NIS identified in the risk identification phase. Similarly, for D11 sufficient time and expertise was available to assess the sensitivity of just 8 of the total 16 species with reported abundances in the study area.

While the RAGES project has demonstrated the clear potential for application of expert judgement approaches to assess the environmental consequences of particular pressures on particular ecosystem elements, large scale implementation of such approaches for practical application to implementation of the directive will require further efforts. The existing approaches and scoring systems could be used to centralise efforts of a broader group of experts in NIS and cetacean ecology and biology, in a series of workshops to finalize and agree sensitivity scores (for cetaceans) and to rank the NIS according to the scoring system developed for the NIS horizon scanning exercise. For NIS the timeframe for such initiatives could in principle be aligned with the cycle of MSFD implementation. Such an initiative would enable a common basis for assessment at the beginning of each MSFD cycle. The cetacean sensitivity index, once agreed by a sufficiently broad panel of experts, would likely require updating less frequently but should be sufficiently frequent as to ensure the sensitivity index keeps abreast of the latest scientific knowledge (and for the sake of harmonization with the MSFD, a six-year cycle might also be appropriate).

EVIDENCE BASE

The deliverables of the RAGES project have focused on developing a generic RBA, applying it to two descriptors which entail high levels of uncertainty, as described above. Whereas any attempt to manage human activities and environmental problems may be considered in terms of risk, certain descriptors of the MSFD entail more uncertainty than others, and the evidence base to support fully quantitative approaches to the analysis of some activity-pressure-state causal chains is not fully developed, and the RAGES risk approach has been designed in response to such conditions. Deliverable 5.1 considers some other aspects of the Directive that may be amenable to our simple RBA. Cormier et al (2017) advocate for the use of bow-tie approaches for the assessment of risk analysis and have developed hypothetical models for the application of such approaches, but to date these have seen limited practical application in the implementation of the MSFD. In our two applications (regardless of individual MS national capacity for the implementation of the MSFD and of dedicated resources) there are still a number of fundamental gaps in the evidence base for management for these two descriptors, that can only be filled by dedicated primary research. Many of the questions raised by the MSFD result in uncertainty, and indeed arise from it. The RBA is essential in the implementation of the MSFD until such fundamental research problems are addressed, but such fundamental research is beyond the scope of the competent authorities and their marine directors. Such questions must be addressed through the relevant research funding mechanisms.

Non-Indigenous Species

Regarding the evidence of the impacts of NIS in the subregions examined in the scope of the RAGES project the major source of uncertainty is the lack of information on the distribution and abundance of NIS within MS territories. The long list of sources that was required to compile the initial list of NIS in the subregions illustrates the lack, to date, of systematic efforts to quantify the abundance and distribution of NIS in the region, and this paucity of data is present both at the national, sub-regional and regional scales.

For D2 (NIS) there is also a limited understanding of the exact ecological conditions which may enable a particular species to become established, and/or invasive in a particular location. This results in a limited predictive capacity to identify which new NIS will arrive, or their behaviour and impacts once they do. Furthermore, some NIS with high adverse impacts can be commercially exploited, thus contributing to local economy (e.g. *Ruditapes phillipinarum* in mainland Portugal), other species (e.g. *Mnemiopsis leydii*) have the potential to cause dramatic environmental and economic impacts (Knowler, 2008). In fact, the inability of “invasion biology” to define and predict the types of impacts that may occur represents a major uncertainty (Preyera, 2016) along the causal chain from Pressure to Impact. Therefore, even the use of complex mechanistic models has limited ability to enable appropriate management actions.

Ultimately fully effective methods to understand the distribution, spread and in particular, the impacts of NIS (such as out-competing native species, altering native habitats or economic impacts), will require fundamental insights into the community dynamics of invasion, and the physiological and environmental characteristics which enable establishment and spread.

Continuous Noise

There are significant ongoing efforts to improve the accuracy and reliability of the mapping of sound pressure levels emanating from both impulsive and continuous noise and this is in no small part due to recent attempts at implementation needs of the MSFD. Although these efforts have resulted in the rapid emergence of improved regional and local sound pressure level maps (e.g. Farcas et al., 2020), the link between underwater sounds and changes in environmental state in terms of individual and population level responses of cetaceans to sound sources still entails much uncertainty. Much research effort over many decades has focused on the impact of noise on cetacean species, with potential impacts including behavioural changes and displacement resulting from processes such as acoustic masking and hearing loss (Nowacek et al., 2007; Erbe, 2012). However, despite these long-standing research efforts, it has proven very difficult to draw robust statistical conclusions between noise and cetacean behavior and physiology. Without quantitative empirical evidence of noise impacts, the RAGES project needed to develop an expert judgement approach in order to harness the expertise held by a range of experts across Europe.

The RAGES project also encountered challenges in obtaining and analysing distribution and abundance data for cetacean species, for which confidence is low in many cases. This is the case despite repeat, state-of-the-art monitoring of cetacean distribution and density (e.g., Hammond et al., 2017, Rogan et al 2018) in the RAGES study area and is due to the large areas under consideration and the logistics and inherent difficulty in surveying mobile animals over such large areas. For example, for the ObSERVE surveys (Rogan et al., 2018) the errors associated with abundance estimates (Coefficient of Variation (CV)) of cetacean species range from relatively low values to very high values (e.g. for the Summer 2016 period, the ObSERVE report shows a range of values from 10,675 (**CV: 16.5%**) Harbour Porpoise, 1987 (**CV:27%**) Minke Whales and 95 (**CV:73%**) Fin/Sei Whales. This results in a situation where even if the science of underwater noise modelling continues to advance and the pressures of underwater noise are mapped with great accuracy and precision, there is a mismatch with the certainty associated with the density of the impacted species. As a consequence of these uncertain relationships between cetacean response and underwater noise and their implications for species behaviour and ecology, the development of increasingly accurate and precise underwater noise models may add little to our understanding of the trends in cetacean abundance or distribution. This means that there is a very important role for expert judgement and risk-based approaches until such time as the evidence base improves.

RECOMMENDATIONS

Data gathering, archiving and sharing

Harmonised regional assessment of Good Environmental Status cannot rely on ad-hoc data collection and exploitation of individual professional networks. Free availability of relevant datasets should be ensured in compliance with MS and Commission obligations under the stipulations of the Aarhus Convention on Access to Information, Public Participation and Access to Justice in Environmental Matters (United Nations Economic Commission for Europe, 1998), for which data sharing, data archive centres and freely available environmental data are central pillars.

Key Specific Recommendations

- Centralized efforts providing data on human activities in the marine environment (e.g. EMODnet, Copernicus) have an invaluable role to play in the regional harmonization of MSFD implementation. Opportunities to add value and maximise the potential for proxy datasets to be adapted for estimation of pressures should be explored. For example, a freely available EU scale map of maritime transport (including more offshore shipping) that can be accurately related to noise.
- Freely available maps of the main NIS introduction pathways, updated yearly, at the sub-regional/regional scale to promptly inform monitoring of areas at higher risk of NIS introductions are a prerequisite for efficient regional implementation. MS should ensure that data are freely available and meet common minimum standards.
- Common standards on NIS terminology and reporting should be established and utilized in the implementation of the MSFD.
- Accessibility of MS reporting data should be improved. The cyclical reviews of MS reporting may provide an opportunity to archive MSFD implementation data centrally to improve accessibility.
- Regular updating of NIS data on the EASIN database (at least on a 6-year basis, following Article 17 of the MSFD, but ideally every year) in order to provide reliable and accurate information to support risk assessments at the sub-regional/regional scales.
- A harmonised EU-scale database of cetacean density distribution – spatially standardised, freely available and with appropriate metadata.

Expert approaches

Expert judgement approaches have the potential to greatly improve the efficiency and effectiveness of regional cooperation and national implementation. Structures and processes to enable the participation of experts in focused expert judgement workshops should be established centrally at the Community Level.

Key Specific Recommendations

- Establishment of a Task Group under the Marine Strategy Coordination Group. Based on the findings of the RAGES project the Terms of Reference for such a group could include:
    - Identification of descriptors and criteria for which risk-based approaches may be most appropriate.
    - Agreeing methodologies for the collection of expert judgement on descriptors and criteria.
    - Establishing expert networks and workshops to facilitate the practical feasibility and functionality of these groups.
- Assembling a panel of experts to assist the HS Horizon-Scanning approach to rank and identify top-priority NIS at sub-regional/regional level
- Assembling a panel of experts to apply the sensitivity approach to cetacean species at subregional and regional scales.

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