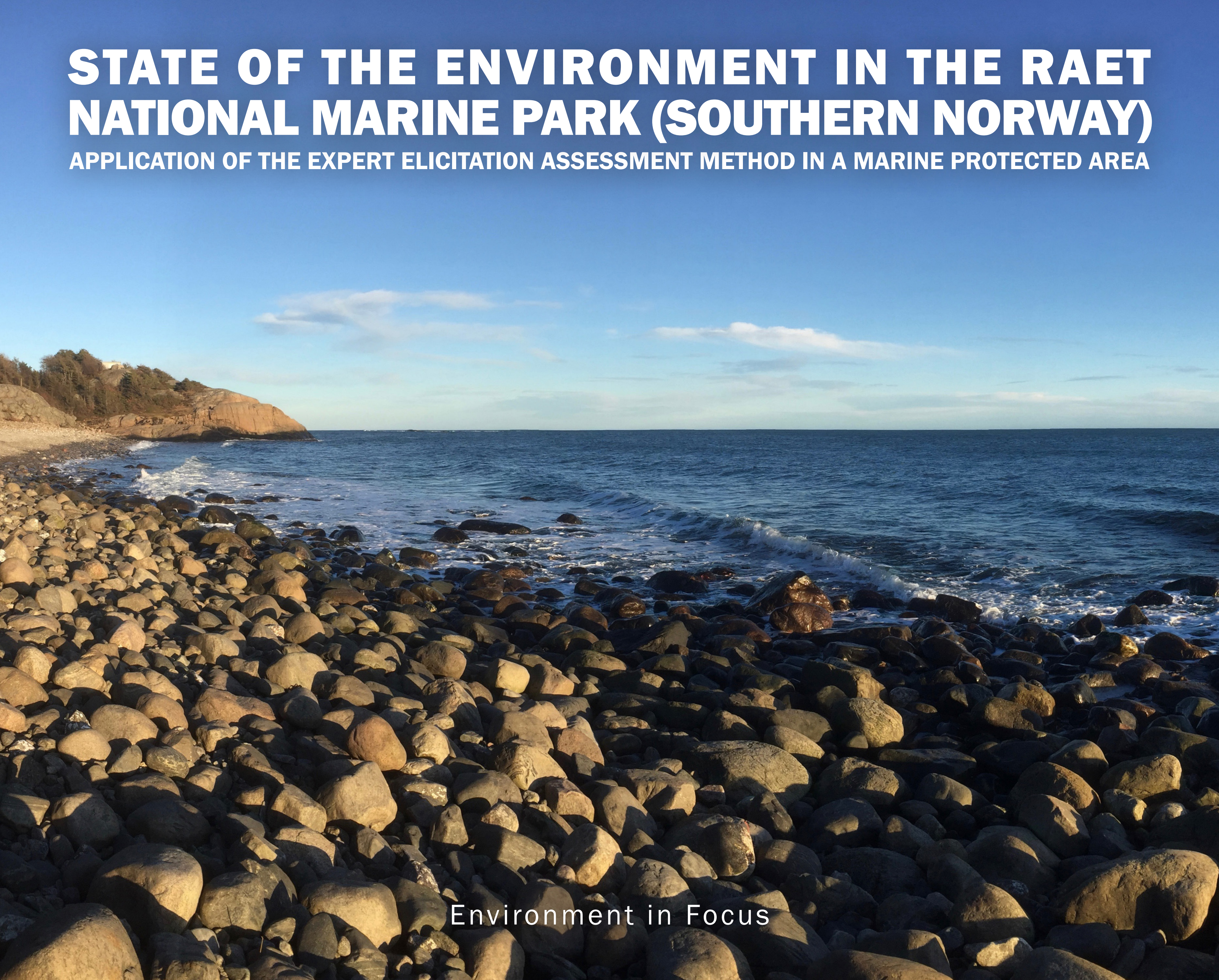
STATE OF THE ENVIRONMENT IN THE RAET NATIONAL MARINE PARK (SOUTHERN NORWAY)

APPLICATION OF THE EXPERT ELICITATION ASSESSMENT METHOD IN A MARINE PROTECTED AREA



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STATE OF THE ENVIRONMENT IN THE RAET NATIONAL MARINE PARK (SOUTHERN NORWAY)

APPLICATION OF THE EXPERT ELICITATION ASSESSMENT METHOD IN A MARINE PROTECTED AREA

Authors Peter T. Harris[1], Joan Fabres[2], Morten Sorensen[2], Wouter Rommens[2], Elaine K. Baker[3], Tone Kroglund[4], Kari Grundvig[5], Frode Kroglund[6], Thomas Kiland-Langeland[6], Jan Atle Knutsen[7], Halvor Knutsen[7,8], Dag Olav Andersen[8]

Photography Peter Prokosch

1. Corresponding Author, GRID-Arendal, Postboks 183, 4836 Arendal, Norway, Peter.Harris@grida.no, Tel. +47 4763 0434
2. GRID-Arendal, Postboks 183, 4836 Arendal, Norway
3. GRID-Arendal c/o University of Sydney, School of Geosciences, Sydney, Australia
4. Norwegian Institute for Water Research (NIVA), Gaustadalléen 21, 0349 Oslo, Norway
5. Norwegian Directorate of Fisheries (Fiskeri-direktoratet), Postboks 185 Sentrum, 5804 Bergen, Norway
6. Aust- and Vest-Agder County Governor's Office
7. Institute of Marine Research (IMR), Nye Flødevigveien 20, NO-4817 His, Norway
8. University of Agder, Postboks 422, 4604 Kristiansand, Norway.



Contents

Foreword

The Raet National Marine Park, on the south coast of Norway, is the newest addition to Norway's marine protected area network. It is an area of great natural beauty, with a vast variety of plant life, animal life and geology. It is also an area with a rich cultural history and historical significance.

Marine protected areas are essential tools to ensure healthy oceans. It is important that the management policies of these vulnerable and valuable areas are based on the best scientific information available. This report outlines an innovative and comprehensive new approach to support the development and evaluation of such policies. It includes the input of marine scientists, but also the input from the fishing industry, the tourism industry and a range of other stakeholders. In bringing a large set of experts together, we also recognize the local and traditional knowledge about our marine environment. This report provides us with a solid understanding of the status and trends in the marine environment in the National Marine Park.

It is the first time this method has been applied for state of the marine environment reporting in Norway. The good news is that the report broadly concludes that the Raet National Marine Park is in good condition. However, it also points out significant information gaps we must address, and areas where new management measures are needed.

It is an important goal for the Norwegian government to make sure that our environmental policies are effective, and that any negative changes in the environment are identified promptly. This report makes a valuable contribution towards reaching that goal for the Raet National Marine Park.

Vidar Helgesen
Minister of Climate and Environment

Executive summary

We document a procedure for conducting a State of the Marine Environment assessment using the expert elicitation (workshop-based) method, including a new web-based tool for real-time feedback to participating experts.

The method is applied to the newly declared 607 km2 Raet National Marine Park located in southern Norway, where a workshop was held with 20 experts with local knowledge of the environment, including its social and economic aspects.

The strengths and weaknesses of the expert elicitation method are discussed and it is concluded that the method is suitable for conducting an assessment at the scale of this marine park.

The method enables the rapid production of a cost-effective product that provides an assessment that is relevant to the park's management and which makes use of all available knowledge (including local and unpublished knowledge and information), with distinct advantages over costly, data-generated assessment methods. Although there is a marine research station located within the boundaries of the park, several data gaps have been identified for some habitats, which could not be assessed using the available data.

New management regimes are needed for some species that are overfished (European lobster, Homarus gammarus) or threatened by other human activities (sugar kelp habitat).

Overall, the environment within the park is considered to be in generally good condition.

1. Introduction

1.1 State of the Marine Environment assessment

It is fundamental to marine environmental management that governments have the capacity to assess and monitor the condition and trend of coastal and marine ecosystems within their jurisdiction (UNEP and IOC/UNESCO, 2009). Although undertaking integrated environmental assessments[1] can be expensive and time-consuming, sound information is critical to understanding the State of the Marine Environment (SOME) to underpin decision-making, achieve or maintain ocean health and develop national oceans policies (UNEP and IOC/UNESCO, 2009). Most importantly, large-scale integrated assessments must not be overly biased by information that is limited only to places or issues that are well studied, since this might result in outcomes that are not balanced or that do not properly represent conditions across the whole of the area assessed (e.g. Martin et al., 2012).

SOME assessments (e.g. Wilkinson et al., 2005; OSPAR, 2010; Australia State of the Environment 2011; EPA, 2015; United Nations World Ocean Assessment, 2016) provide authorities with information on the issues that they must address, any gaps in knowledge that may exist and the social and economic consequences that are likely to follow from policies and legislative actions taken. In the case of countries that have established marine protected areas (MPAs) within their jurisdictions, there is an additional need to monitor and measure the condition and trend of ecosystems and their surrounding areas to verify that the MPA is performing as planned to yield the desired outcomes (Pomeroy et al., 2004).

Although data sets from local areas – including data sets about specific aspects of marine ecosystems – are common, these often have too coarse a resolution over the whole of the area being assessed and are usually not part of a systematic collection of data routinely synthesized for reporting purposes (Carpenter, 2002; Ward, 2011). Regional and national data sets are often patchy or lacking (e.g. Ban et al., 2009; Smith et al., 2009), making it difficult to establish a baseline against which to measure future changes and to select indicators that can be monitored and measured. Furthermore, since there are many existing frameworks and approaches to environmental assessment and reporting (Singh et al., 2012; Rombouts et al., 2013) and currently no globally accepted schemes (Ward, 2014), knowing how to approach the conduct of an SOME assessment can be a challenge.

Here we report on the application of the expert elicitation (EE) method to conduct an SOME assessment to support the management of the Raet National Marine Park, a newly declared MPA in south-eastern Norway. EE is essentially a scientific consensus methodology, aimed at generating an assessment of any chosen set of parameters by synthesizing the information available from existing assessments, scientific publications and data in conjunction with the subjective judgment of experts (EPA, 2011; McBride and Burgman, 2012; Morgan, 2014; Ward et al., 2014). In the case of an SOME assessment, the EE method is used to assess the condition of the national or regional marine and coastal environment in a manner that can be used for reporting purposes (Ward, 2014). The EE method has been successfully applied for SOME assessments on several occasions, including in the 2011 Australia SOME report (Australia State of the Environment, 2011; Ward, 2014; Ward et al., 2014), in an assessment of the South China Sea (Ward, 2012; Feary et al., 2014), in the Guinea Current Region of West Africa and in Sierra Leone (EPA, 2015).

1.2 The Raet National Marine Park

The Raet National Marine Park (hereafter referred to as the "Raet Park") was established on 16 December 2016, in recognition of the cultural and geological significance of the coastal landscape left behind when the Scandinavian ice sheet withdrew after the last ice age, approximately 10,000 years ago. The term "raet" refers to glacial moraine deposits comprised of cobble- to boulder-sized gravel, which occur offshore and along the coast of Vestfold, Telemark and Agder in southern Norway (Figure 1). The moraine follows the Baltic Coast, from Norway through Finland and Sweden into Russia (Dahl et al., 2014).

The Raet Park covers an area of 607 km2 on the outer coastline of southern Norway (Figure 1). The underwater seascape, dominated by glacial moraine areas and productive kelp forests, is an area of high biological diversity, including fish, crustacea, benthic algae, molluscs and worms (Knutsen et al., 2010; Dahl et al., 2014). In sheltered and shallow-water coastline areas, soft-bottom habitats and eelgrass

1. An integrated environmental assessment is defined as one that includes environmental, social and economic aspects and covers all parts of the environment including habitats, species and ecological, physical and chemical processes (UNEP, 2009).

and mudflat communities occur. Glacially-formed bathymetric depressions on the inner shelf can trap water masses for extended periods such that the bottom water becomes depleted in dissolved oxygen, although anoxic bottom-water conditions have not been found in any locations to date (Dahl et al., 2014).

Biodiversity in hard-bottom communities (macroalgae and macrofauna) and soft-bottom fauna have been examined, and nutrients, water quality and hazardous substances have been studied (Moy et al., 2015; Green et al., 2010; see also http://vannmiljo.miljodirektoratet.no). The Norwegian Institute of Marine Research (IMR) holds an extensive database on Skagerrak (and the Raet Park) coastal marine life, including a beach-seine time series that has been conducted annually since 1919, which samples more than 110 stations along Skagerrak (e.g. Barceló et al., 2015). Meanwhile, a gill-net time series from 1984 to the present day (excluding the 1990s) provides a different range of generally bigger fish and other species (Olsen et al., 2008; Roney et al., 2016). Norway has an ongoing programme for mapping marine habitats along Skagerrak, focusing on eelgrass, kelp forest and fish spawning grounds (Knutsen et al., 2007; Olsen et al., 2008; Bekkby et al., 2012; Espeland et al., 2013; Barceló et al., 2015; Roney et al., 2016).

1.3 Aims and objectives

The aim of this report is to describe the application of the EE assessment approach to a marine protected area and to determine the strengths and weaknesses of this methodology. Its objective is to produce an environmental assessment of the Raet Park, including an assessment of knowledge gaps and potential future environmental risks, for the consideration of regional management authorities. An analysis of the EE method will determine its appropriateness for SOME assessments in a local (subnational) setting.

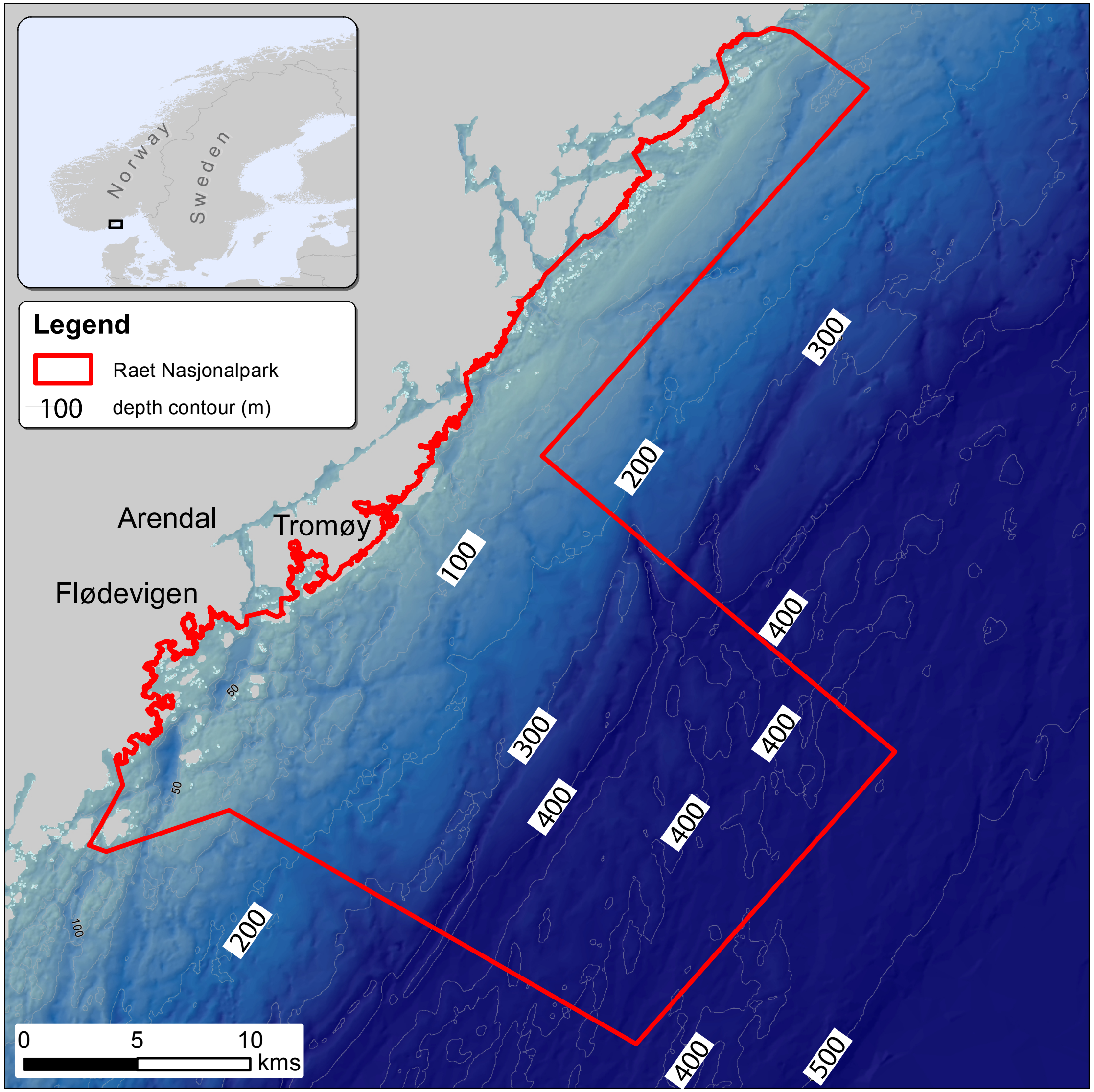


Figure 1: *Map showing the location of the Raet Park in south-eastern Norway. More than 98 per cent of the park area consists of sea, with some land area and a number of small islands also included. The park extends up to about 12 nautical miles offshore, with water depths mainly <100 m except for the deeper areas south of Tromøy, where a maximum depth of up to ~500 metres occurs. The park is representative of deep-water Norskerenna habitat, as well as a broad spectrum of marine habitats associated with the raet glacial moraine (Brattegård and Holte, 1995).*

2. Methods

2.1 Expert elicitation assessment process

The methodology described in this paper is largely based upon the Australia SOME report completed in 2011 (Australia State of the Environment, 2011; Ward et al., 2014). Technically, the method can be described as a form of behavioural aggregation using a modified Delphi Technique with direct discussion (Burgman, 2005). The ultimate success in the production and legitimacy of a report ensuing from an EE process depends upon the thoroughness of the steps before and after the elicitation has been carried out (Kristensen et al., 1999; Martin et al., 2012; McBride and Burgman, 2012). An ideal procedure should include certain steps (Figure 2) tailored to the needs and constraints of the state or region for which the report is being produced. The centrepiece of an EE assessment is the workshop (or series of workshops) attended by appointed experts (Figure 2). A new innovation reported here is a web-based SOME software developed by GRID-Arendal (appendix 1), which is used to record scores assigned by consensus using the modified Delphic approach defined by Macmillan and Marshall (2006).

2.2 Assessment parameters

For the condition assessment, the present SOME-EE process uses standard parameters that are consistent with the United Nations World Ocean Assessment (United Nations World Ocean Assessment, 2016). In the present study, the following sets of parameters were assessed: 1) habitats; 2) species; 3) ecological processes; 4) physical and chemical processes; 5) pests, introduced species, diseases and algal blooms; and 6) pressures and socioeconomic benefits.

2.3 Grading scores, grading statements and benchmarks

During the assessment workshop, expert participants assign condition scores to each parameter on a scale from 1 to 8, whereby 1 designates the poorest state of condition, and 8 the best. Scores are assigned on the basis of group consensus. Based on the scores agreed by the experts, four grades are derived as follows: 1 to 2 = Very Poor, 3 to 4 = Poor, 5 to 6 = Good and 7 to 8 = Very Good.

A key part of the process is applying a set of grading statements (see appendix 2) that have been uniquely derived for each major aspect of the assessment to represent the four condition grades (Very Poor, Poor, Good, Very Good), based on Ward (2011) and the Australia State of the Environment (2011). Each score is also assigned a confidence estimate (High, Medium or Low) based on the experts' current state of knowledge and judgment.

A "benchmark" (a point of reference for the condition) is used to avoid problems of "sliding baselines" (Dayton et al., 1998; Borja et al., 2012; McClenachan et al., 2012). A benchmark year of 1900 was chosen in the present study, since most scientific observations in the Raet Park are subsequent to that date. The use of a benchmark is only for the purpose of quantifying environmental change relative to the present time and should not be confused with an objective for management (Ward, 2014).

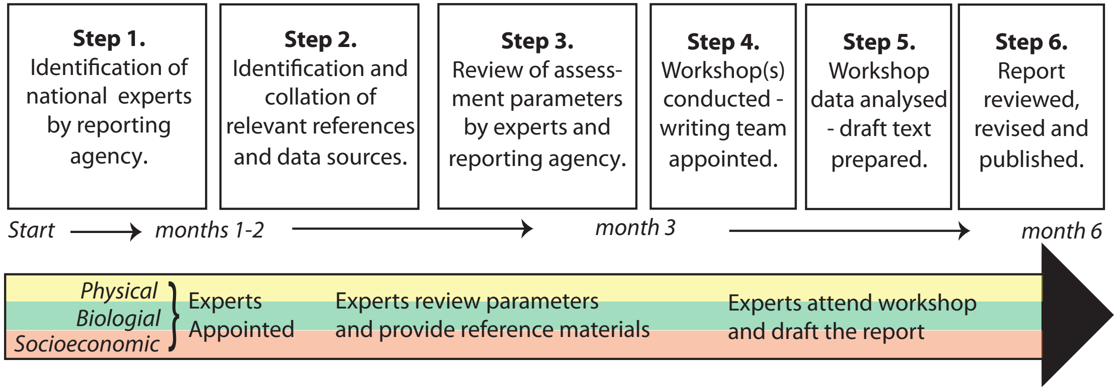


Figure 2: *Diagram illustrating the timeline for one complete cycle of the SOME-EE process. Between three and six months are normally needed to plan and execute the complete process.*

2.4 Assessment of condition

In the assessment workshop, scores are given for three aspects of each condition parameter, in a spatial reference frame (Figure 3): 1) the condition in the most-impacted 10 per cent of the region under consideration; 2) the condition in the least-impacted 10 per cent of the region under consideration; and 3) the condition in the majority (the remaining 80 per cent) of the region under consideration. The use of the upper and lower 10 per cent estimates follows from the Speirs-Bridge et al. (2010) method to reduce the level of overconfidence in expert judgment. Capturing the (lack of) availability of spatial information about each parameter is part of the knowledge gap analysis and is valuable in its own right (Ward, 2014). Otherwise, if there was a lack of spatial data on a parameter (or if the spatial aspects of the parameter were ill-defined), the experts may have decided to score only the whole (100 per cent) area, without scores for the best or worst 10 per cent.

The trend in each parameter is assessed as either declining, stable or improving for the last five years (and not in relation to the benchmark), to provide policymakers and decision makers with feedback on whether or not policy responses have had the desired effect. The choice of five years is based on the typical recurrence interval of SOME reporting in many states and also the fact that it is unlikely that measurable differences in condition could be detected in less than five years following government-led policy changes. A confidence estimate (High, Medium, Low) is also assigned to trends agreed by the experts. Key papers or reports that support the scores being assigned are recorded by the rapporteur; some may become "anchors" for establishing the condition or trend of a given parameter (or set of parameters).

2.5 Assessment of pressures and socioeconomic benefits

To score the environmental impact of marine-based industries (pressure), experts provide a consensus score, confidence grade and estimate of trend (in the last five years) for the condition of the environment that coincides with the spatial footprint (i.e. the space where the industry operates) of the industry, relative to the baseline. Changes in the condition of the environment should be attributable only to the industry under assessment. The confidence score may be influenced by uncertainty in the attribution of impact where two or more industries are impacting on the same area.

The totality of all socioeconomic benefits that society receives from the industry is then assessed. Several aspects must be evaluated, including: 1) whether it is a major national employer, paying fair wages, either through direct employment or supporting industries; 2) whether the state receives significant taxes, royalties and/or licence fees and whether a significant portion of profits remain in the country; 3) whether the industry exploits a sustainably managed renewable resource; 4) whether the industry contributes to education and training programmes, human health or medical benefits for its employees; 5) whether the industry creates national infrastructure such as roads, communication systems or other facilities; 6) whether the industry is mainly or wholly owned by national interests (i.e. the profits from the industry remain in the country). The industry is given a score from 1 to 8 based on the experts' judgment. The environmental and socioeconomic scores for the industry are used to classify its overall rating.

2.6 Risk assessment

The likelihood of and consequences associated with a given risk are scored on a scale from 1 to 5. The risk assessment includes the likelihood that an event will occur: a) in the next five years; and b) in the next 50 years and its consequences (see also Kaplan and Garrick, 1981; FAO, 2016).

2.7 Conduct of the workshop

In order to assess the environmental status of the Raet Park, an EE workshop was conducted on 21-22 August 2014. The workshop was attended by 20 experts (the authors plus the volunteers listed in the acknowledgements) and was conducted according to the methodology outlined above. The results were recorded using software developed by GRID-Arendal (see appendix 1).

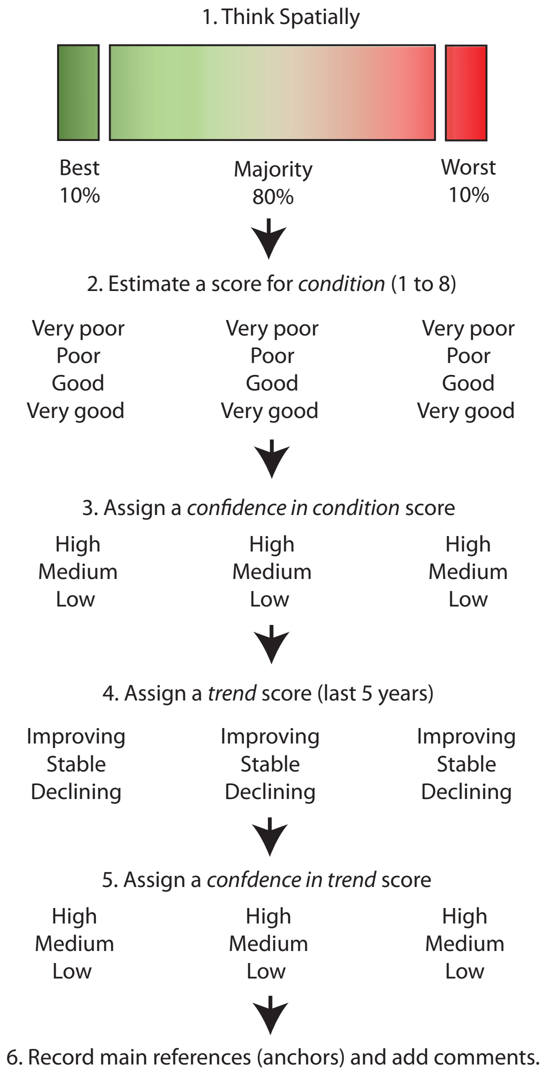


Figure 3: *Flow diagram illustrating steps to be taken in the assessment of each parameter for habitats, species, ecological processes, physical and chemical processes and human pressures. Note that all the scores are ideally assigned for the best 10 per cent, worst 10 per cent and majority (80 per cent) of the area where each parameter applies.*

3. Results

During the workshop held for the present study, the authors volunteered to participate in the subsequent report-writing and thus self-nomination avoided any conflict of interest. The results of the workshop are as follows:

3.1 Habitats

Of the 17 habitats thought to potentially exist in the Raet Park that were identified prior to the EE workshop (Knutsen et al., 2010; Dahl et al., 2014), the participating experts considered that there was sufficient evidence to provide an assessment for only eight of them (Figure 4). The nine habitats not assessed were: anoxic soft bottom; anoxic hard bottom; coral; aphotic hard bottom, including rock and gravel; aphotic soft bottom; euphotic soft bottom; shell sands; salt marsh; and algal wracks.

Figure 4: *Screen shot from the SOME web-based software (appendix 1), showing a list of known or expected habitats in the Raet Park region, with scores for condition (white boxes), trend (arrows or horizontal line) and confidence (coloured squares) produced using GRID-Arendal's web-based system (appendix 1). The solid black line represents the range in condition scores from the worst 10 per cent to the best 10 per cent for the specified habitat. See Table 1 (appendix 2) for grading statements used to derive the scores. Scores were not provided for habitats where the experts considered there to be insufficient information or evidence available to make an assessment. Hovekilen is the name of an embayment within the Raet Park (on Tromøy Island; Figure 1), commonly frequented by tourists and leisure boaters. The "i" symbol is a weblink to text data entered by the rapporteur relevant to the parameter and discussion of the experts.*

Of the eight habitats that were assessed, three were scored with a high degree of confidence (sugar kelp, Zostera eelgrass meadows and rocky foreshore-beach (= rocky littoral zone)), three with a moderate degree of confidence (estuaries and small bays, euphotic hard bottom and large kelp) and two with low confidence (Hovekilen and soft sediment foreshore-beach). The long-term monitoring programme has shown good conditions for hard-bottom vegetation (kelp) in the Raet Park (Moy et al., 2015). Local surveys have also shown good conditions for the rocky littoral zone, soft-bottom fauna and water quality within the Raet Park (Kroglund et al., 2004, 2012).

Moy and Christie (2012) assessed the condition and trend of sugar kelp (Saccharina latissima) habitat for southern and western Norway during 2004–2009 and recorded a large-scale shift from sugar kelp forest to communities dominated by filamentous, ephemeral macroalgae. They attributed this shift mainly to eutrophication (nutrient and particle pollution) and climate change (increase in ocean temperature).

The average condition of habitats is assessed as good to very good (Figure 4). Habitats in the 10 per cent area worst affected by human activities were assessed as being in poor condition, whereas the habitats in the 10 per cent least affected area were assessed as being in very good condition (Figure 4).

The trend for habitat condition over the preceding five years (2009–2014) is assessed as being steady for six out of eight habitats and improving for two habitats (sugar kelp and Zostera eelgrass meadows; Figure 4). No habitat is considered to be in a state of decline.

3.2 Species

Of the 22 species thought to potentially exist in the Raet Park that were identified prior to the EE workshop, the expert participants considered that there was

Component	Info	Assessment grade				Confidence	
		Very poor	Poor	Good	Very good	In grade	In trend
Whales							
Seals				Stable		Low	Low
Porpoise			Improving			Low	Low
Resident birds - small gull species	(i)		Stable			High	High
Migratory birds - terns	(i)		Stable			High	High
European oyster				Stable		Low	Low
Blue mussel					Stable	High	High
Pandalus borealis				Stable		Moderate	High
Crabs					Stable	Low	Moderate
Lobster			Stable			High	High
Coastal cod			Stable			High	High
Other cod fishes			Stable			Moderate	Moderate
Leppefisk (Berggylt etc.)	(i)				Stable	High	High
Sea trout					Improving	High	High
European eel		Stable				Moderate	Moderate
Spratt (Sprattus sprattus)			Unclear			Low	Low
Herring				Stable		Low	Low
Makrell					Stable	Moderate	Moderate
Piggho (shark or dogfish)							
Large gulls				Stable		High	High
Cormorants					Improving	High	High
Flatfishes				Stable		Low	Low

Grades: Very poor, Poor, Good, Very good

Recent trends: Improving; Stable; Declining; Unclear; Worst/best 10% of places

Confidence: High confidence based on high-quality data; Moderate confidence based on some limited evidence; Low confidence based on expert judgement with little or no data sufficient evidence to provide an assessment for 20 of them (Figure 5). They found that insufficient data were available to score the best and worst 10 per cent of areas of species occurrence (spatially) and hence scores were provided for the total area only.

Of the species that were assessed for their current condition, nine were scored with a high degree of confidence, four with a moderate degree of confidence and seven with low confidence. Published papers and reports supporting the assessment of the condition and trend of species include Juliussen (2013), who examines the biodiversity of fish species in a gill-net time series, and Barceló et al. (2015), who describe the historic changes in species composition in the beach-seine survey from 1919 until the present day. The average condition of species is assessed as good, although the European eel is considered to be in very poor condition and seven other species are considered to be in poor condition (Figure 5).

The local European lobster (Homarus gammarus) fishery has been in decline for many years (Pettersen et al., 2009) and there are strong indications that the stock is over-harvested; the fishery is poorly regulated and the total estimated catch might be 14 times higher than official reports suggest (Kleiven et al., 2012). Rebuilding the lobster population within existing MPAs has further shown that fishing pressure is an important contributor to stock decline (Moland et al., 2013).

__Figure 5:__ Screen shot from the SOME web-based software (appendix 1), showing a list of known or expected species in the Raet Park region, with scores for condition (white boxes), trend (arrows or horizontal line) and confidence (coloured squares); figure produced using GRID-Arendal's web-based system (appendix 1). See Table 2 (appendix 2) for grading statements used to derive the scores. The experts did not provide condition scores for the best or worst 10 per cent of species due to insufficient data. Scores were not provided for whales or sharks (including dogfish) because the experts considered there to be insufficient information or evidence available to make an assessment. The "i" symbol is a weblink to text data entered by the rapporteur relevant to the parameter and discussion of the experts.

The trend for species condition over the preceding five years (2009–2014) is assessed as being steady for 16 of the 20 species assessed, improving for three species (harbour porpoise (Phocoena phocoena), sea trout (Salmo trutta trutta) and cormorants (Phalacrocorax carbo)) and uncertain for one species (sprat (Sprattus sprattus); see Figure 5). No species is considered to have been declining in condition over the last five years.

3.3 Ecological processes

Experts participating in the workshop assessed five ecological processes: 1) migration routes for salmon, eel and sea trout; 2) bird nesting and roosting sites; 3) feeding grounds; 4) trophic structures and relationships; and 5) primary productivity.

The migration routes for Atlantic salmon (Salmo salar), sea trout (Salmo trutta trutta) and eels (Anguilla anguilla) are assessed with a high degree of confidence as being in very good condition. Two of the most significant commercial fish species caught within the Raet Park do not spawn within the park itself: European eels spawn in the Sargasso Sea, with eels from eastern parts of Europe passing through the park on their migration run (Westerberg et al., 2014), while sea trout spawn and utilize nursery habitats in surrounding streams and brooks that discharge along the coast beyond the park (Durif et al., 2011). A recent survey of many of the sea trout brooks bordering the Raet Park has found their present status to be moderate, ranging from good to poor (Haraldstad et al., 2014; Agder, 2015). A key point, therefore, is that human actions outside the park will affect fish status within the park.

Although salmon lice (Lepeophtheirus salmonis) are regarded as the most significant challenge to the survival of anadromous fish in Norway in general, eight years of monitoring have shown that they are not affecting anadromous fish within the Raet Park (Nilsen et al., 2016). Atlantic salmon from rivers east of the Raet Park most likely pass within the boundaries of the Raet Park on their marine migration run. There are no migratory barriers to anadromous or catadromous fish within or outside the Raet Park, but oceanic factors will affect survival to adulthood. Acidification of freshwater streams was the prime cause for species extinction during the 1960s and liming since the mid-1990s has resulted in a major increase in survival and in salmon catches within the region (Hesthagen et al., 2011). Current pressures still affecting anadromous and catadromous fish are mainly related to hydropower. Sea trout are affected mainly by road-related barriers (Haraldstad et al., 2014; Agder, 2015).

Nesting and roosting sites for seabirds such as terns and cormorants on the Raet Park islands and coasts are considered to be in good condition, although the worst 10 per cent of areas are considered to be in poor condition (Fauchald et al., 2015). Feeding grounds are considered to be in good condition with a moderate degree of confidence, although the worst 10 per cent of areas are considered to be in poor condition. Trophic structures and relationships are considered, with a high degree of confidence, to be in poor condition (Knutsen, 2010). Lastly, primary production is assessed as being in good condition with a high degree of confidence (Andersson et al., 2006), although the worst 10 per cent of areas are considered to be in poor condition.

The trend for the condition of ecological processes over the preceding five years (2009–2014) is assessed as being steady for all processes assessed, although there is a confidence score for only two of these trends. No ecological process is considered to be in a state of declining condition.

3.4 Physical and chemical processes

Experts participating in the workshop assessed four physical/chemical processes: 1) coastal currents; 2) urban discharge; 3) freshwater run-off; and 4) dissolved oxygen content. All four were assessed as being in very good condition. The participants found that insufficient data were available to spatially score the best and worst 10 per cent of areas of physical and chemical processes; hence scores were provided for the total area only. There is, however, a high degree of confidence in the condition and trend assessments for all four processes (Agder, 2015).

The trend for the condition of physical-chemical processes over the preceding five years (2009–2014) is assessed as being steady for coastal currents and dissolved oxygen, improving for urban discharge and declining for the quality of run-off. Run-off from watersheds has become steadily darker over the last 20–30 years due to organic matter content. This may affect light transmission within the coastal waters (Aksnes et al., 2009).

3.5 Pests, introduced species, diseases and algal blooms

The overall status of pests and invasive species was assessed by workshop participants as being good with reference to the benchmark of 1900. The condition in the worst 10 per cent of areas was assessed as being poor and in the best areas the status was assessed as being good. However, over the last five years the condition is, with a high degree of confidence, assessed as declining (Gederaas et al., 2012).

Diseases are not well studied in the Raet Park and were not assessed as part of the workshop.

Algal blooms (Chrysocromulina polylepis) have not occurred on a large scale in the region since the last major bloom in 1988, which affected many marine species. As algae species have not been monitored, the experts decided not to score this parameter.

3.6 Pressures and socioeconomic benefits

The workshop considered six separate human pressures and the socioeconomic benefits that they provide to society in the Raet Park region: commercial fisheries; recreational fisheries; commercial shipping; recreational boating; tourism; and coastal development (Figure 6). The participants found that insufficient data were available to spatially score the best and worst 10 per cent of areas of most parameters, but there was sufficient information to score the best and worst 10 per cent of areas for pressures of commercial fishing, recreational fishing, tourism and coastal development (Figure 6).

For commercial fisheries, the experts considered the environmental pressure to be moderate (good) overall, with the worst 10 per cent of areas impacted by fishing experiencing significant pressure and the best 10 per cent of areas experiencing low, but increasing (declining condition) pressure over the past five years (indicating increasing pressure on the areas in best condition where commercial fishing occurs; see above for “species” regarding the European lobster fishery). The confidence in the environmental impact of this pressure, and its trend over the past five years, are considered to be low (Figure 6). The experts consider commercial fishing to be providing significant (good) social and economic benefits to the region.

For recreational fishing, the experts considered the environmental pressure to be moderate (good) overall, with the worst 10 per cent of areas impacted by fishing experiencing high pressure (very poor) and the best areas experiencing moderate pressure (good). The trend in this pressure has been steady over the past five years and there is moderate confidence in this assessment. The experts consider recreational fishing to be providing significant benefits (good) to the region, which are believed to have been increasing over the past five years. There is a high degree of confidence in the score and trend for social and economic benefits (Figure 6).

Figure 6: *Screen shot from the SOME web-based software (appendix 1), showing a list of some human pressures and social and economic benefits known to occur in the Raet Park region, identified prior to the workshop, with scores assigned during the workshop to the extent of the pressure (white boxes), trend (arrows or horizontal line) and confidence estimates (coloured squares); figure produced using GRID-Arendal's web-based system (appendix 1). The pressure scores should be interpreted in relation to the grading statements listed in Table 6 (appendix 2) and the social-economic scores with reference to Table 7 (appendix 2). In some cases, the experts did not provide condition scores for the best or worst 10 per cent due to insufficient data.*

For commercial shipping, the experts considered the environmental pressure to be moderate (good) overall. The trend in this pressure has been steady over the past five years and there is high confidence in this assessment. The experts consider commercial shipping to be providing the region with high benefits (very good), which are believed to have been increasing during the past five years. There is a high degree of confidence in the score and trend for social and economic benefits (Figure 6).

For recreational boating, the experts considered the environmental pressure to be moderate (good) overall. The trend in this pressure has been steady over the past five years and there is moderate confidence in this assessment. Recreational boating is considered by the experts to be providing the region with high benefits (very good), which are believed to have been steady over the past five years (attributed mainly to recreational boat harbours). There is a low degree of confidence in the score and trend for social and economic benefits (Figure 6).

For tourism, the experts considered the environmental pressure to be moderate (good) overall, with the worst 10 per cent of areas impacted by tourism experiencing moderate pressure (poor) and the best areas experiencing low pressure (very good). The trend in this pressure has been steady over the past five years for most areas but increasing (declining

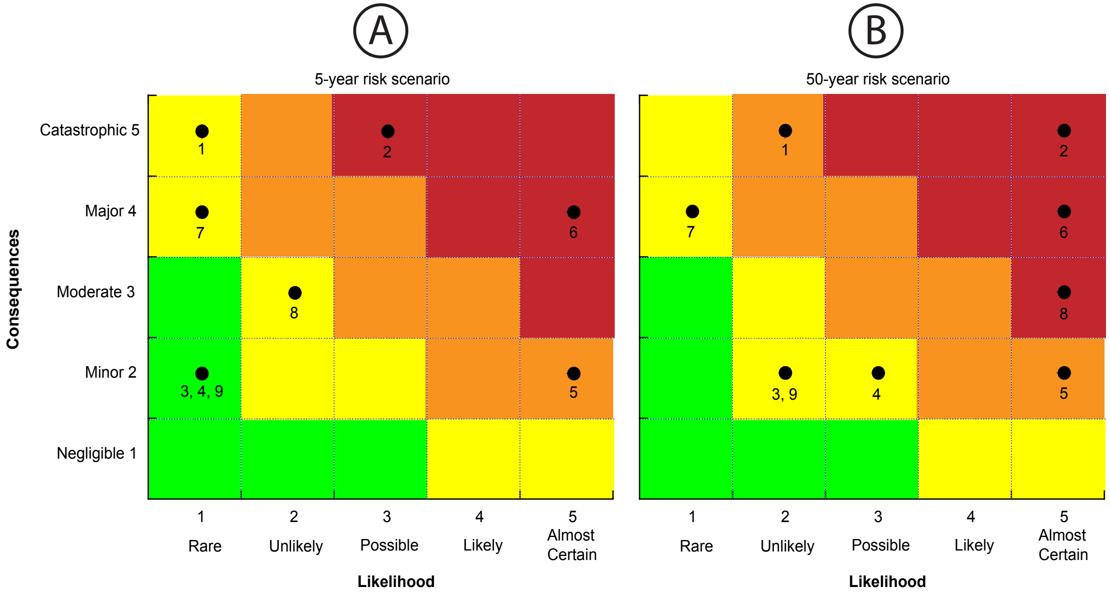
condition) in the worst 10 per cent of areas; there is moderate confidence in the trend assessment. Tourism is considered by the experts to be providing the region with significant benefits (good), which are believed to have been steady over the past five years. There is a high degree of confidence in the score and trend assessment for social and economic benefits (Figure 6).

Lastly, for coastal development, the experts considered the environmental pressure to be significant (poor) overall, with the worst 10 per cent of areas impacted by tourism experiencing high pressure (very poor) and the best areas experiencing moderate pressure (good). There is moderate confidence in the assessment of pressure (Figure 6). The trend in this pressure has been steady over the past five years for all areas and there is high confidence in this trend assessment. Tourism is considered (with moderate confidence) by the experts to be providing significant benefits (good) to the region, which are believed to have been increasing over the past five years. There is a high degree of confidence in the upward trend for social and economic benefits derived from coastal development (Figure 6).

3.7 Risk assessment for the future of the Raet Park

The workshop considered nine separate risk scenarios with five-year (Figure 7A) and 50-year (Figure 7B) time horizons using the assessment procedure outlined in section 2.7. Two risks that the experts assessed as being low for the Raet Park region were the risk of anoxic dead zones appearing and the risk of sea level rise causing coastal inundation (Figure 7A). The two risk scenarios that the experts rated as having the highest risk, and which did not change over five-year and 50-year timescales, were for shipwreck (or accident) causing an oil spill and the risk of catchment disturbance causing elevated turbidity and terrestrial organic matter in coastal waters (Figure 7A and B).

The risk that the use of fertilizers will cause widespread eutrophication (rated as a moderate risk) and that tourism will cause environmental damage (significant risk) did not change between five and 50 years (Figures 7A and B). In contrast, the risk of harmful algal blooms increased from moderate in a five-year scenario to high in 50 years (Figures 7A and B).



C

Group	Risk factor	Risk in 5 years				Risk in 50 years			
		High	Signi-ficant	Mod-erate	Low	High	Signi-ficant	Mod-erate	Low
Overfishing	1. The risk that overfishing will cause fish stocks to collapse			X			X		
Oil spill	2. The risk that shipwreck or accident will cause a major oil spill	X				X			
Sea level rise	3. The risk that global sea level rise will cause coastal inundation				X			X	
Poisoned seafood	4. The risk that pollution will cause seafood poisoning				X			X	
Tourism	5. The risk that tourism will cause environmental damage		X				X		
Turbidity	6. The risk that catchment disturbance will cause elevated turbidity	X				X			
Eutrophication	7. The risk that use of fertilizers will cause widespread eutrophication			X				X	
Algal blooms	8. The risk that harmful algal blooms will occur			X		X			
Anoxia	9. The risk that anoxic (dead zones) will expand				X			X	

Figure 7: *Results of risk analysis carried out for the Raet Park showing (A) likelihood versus consequences scores with a five-year time-horizon; (B) likelihood versus consequences scores with a 50-year time-horizon; and (C) overall risk assessment. The numbers on the likelihood versus consequences graphs (A and B) refer to the risk scenarios listed in (C).*

4. Discussion

4.1 The condition and trend of the Raet Park

One aim of this study was to produce an assessment of the Raet Park, including an assessment of knowledge gaps and potential future environmental risks, for the consideration of regional management authorities. As reported in the results above, the average condition of habitats is assessed as good, although habitats in the 10 per cent area worst affected by human activities are assessed as being in poor condition, and none of the assessed habitats are considered to be in a state of declining condition. One area of concern is that of the 17 habitats in the Raet Park that the IMR mapped, there are sufficient data to comment on the condition of only eight of them (Figure 4). For example, anoxic habitats are thought to exist within perched basins where bottom waters are poorly flushed and infrequently replenished, but data are lacking.

The average condition of species is assessed as good, and although no species is considered to be in a declining condition, the condition of the European eel is considered to be very poor and seven other species are considered to be in poor condition (Figure 5). The local European lobster (Homarus gammarus) is probably overfished and the total catch might be 14 times higher than official reports suggest (Kleiven et al., 2012). Regarding ecological processes, the trend is improving for urban discharge but declining for the quality of run-off. There has been an increase in the numbers of invasive species and marine pests over the past five years.

The spatial information available on species, ecological processes, physical and chemical processes and human pressures is insufficient in most cases to provide scores on the best and worst 10 per cent of areas (spatially; Figures 4 and 5). Managers of the Raet Park will need to know which areas are most exposed to human pressures in order to be able to take marine spatial planning decisions, making this is an important knowledge gap.

The workshop considered six separate human pressures and the economic benefits that they provide to the Raet Park: commercial fisheries; recreational fishing; commercial shipping; recreational boating; tourism; and coastal development. There was concern over the impact of coastal development, which was assigned the lowest score (greatest impact) of all human pressures (Figure 6). Out of nine risk scenarios, the two that the experts considered to be the highest risk were the risk of a shipwreck or accident causing an oil spill and the risk of catchment disturbance causing elevated turbidity in coastal waters (Figure 7A and B).

There are also factors that are beyond the control of the park managers, including the threat of changes in the quality of run-off, increased turbidity and run-off from coastal development and road-building in catchments along the adjacent coast. Invasive species are likely also beyond the control of park managers (although it could be possible to ban the discharge of ballast or bilge water within the boundaries of the marine park).

4.2 The expert elicitation method: strengths and weaknesses

Generally speaking, three main categories of methodologies are used to conduct environmental assessments: 1) indicator-based, data-driven assessments (e.g. UKTAG, 2008; UNEP, 2014); 2) desktop assessments conducted by one or more experts based on a review of available data (e.g. OSPAR, 2010; United Nations World Ocean Assessment, 2016); and 3) assessments based on the analysis of views of experts gathered by questionnaire, using web-based surveys or in a workshop setting (e.g. Australia State of the Environment, 2011; Feary et al., 2014; EPA, 2015). The EE method described in this paper may be classified in the third category of assessment methodologies. It was able to provide a rapid, thorough and scientifically valid summary of the status and trends (with explicit confidence statements) for the State of the Marine Environment within the Raet Park in southern Norway. However, in all such environmental assessment procedures, the methods used have their own strengths and weaknesses, and the EE approach is no exception (Burgman, 2005; McBride and Burgman, 2012).

Among the main strengths of the EE method is the rapid turnaround time to complete an assessment, which under optimal conditions can make it possible to complete an assessment and publish a report within three to six months. This feature lends itself to situations where frequent assessments are needed, for example to gauge the effectiveness of newly enacted government regulations (Feary et al., 2014).

The effectiveness of the EE method is wholly dependent upon the pool of experts appointed by the reporting agency (the party organizing the assessment). Unless the experts participating in the process have the relevant knowledge, the process will be flawed, thereby compromising the quality of the final product. For this reason, Step 1 in the EE process (Figure 2) is critical to its success (McBride and Burgman, 2012).

Provided that a representative group of experts has been appointed, another strength of the EE method is its comprehensiveness and its ability to produce a fully integrated environmental assessment (as defined by UNEP, 2009). The value of an integrated assessment is illustrated by the following example: the condition of estuaries and lochs in Scotland was rated as “very good” by UKTAG (2008) based on the winter mean of dissolved inorganic nitrogen over a six-year period (2001–2006). However, the ecology of at least one of these Scottish bodies of water (the Firth of Clyde) has been described by Thurstan and Roberts (2010) as “a marine ecosystem nearing the endpoint of overfishing, a time when no species remain that are capable of sustaining commercial catches”. Hence, while the water quality in this firth may be rated as very good, the ecosystem has been significantly impacted by overfishing; information that an integrated assessment would capture. This example illustrates the danger of relying too heavily upon individual indicators to provide an assessment of overall environmental condition.

One criticism of the EE method is that it is not quantitative and that the outcome is heavily dependent upon the judgment of individual experts (e.g. the expert frailties listed by Burgman, 2005). The EE method asks experts to provide their qualified opinion on the condition and trend of habitats, species, ecological processes, etc., which might produce an incorrect assessment (albeit qualified by a statement of confidence limits) due to overconfidence (Burgman, 2005). The approach used here of requiring consensus before recording a score (a form of aggregation) may reduce the effects of individuals being overly confident in their assessment (because extreme views are averaged out).

Of course, the same criticism applies to any method in which expert opinion or judgment by an individual plays a role. Even quantitative data requires an expert to produce an interpretation of the results. Testing the validity of any interpretation is the purpose of peer reviewing the final report, which is included in the EE method (Step 6; Figure 2) in the same way as any other assessment method. The value of expert opinion on status or trend provided with low confidence may be debated; at the very least, it does serve the purpose of highlighting where data gaps exist and where further research may be needed to increase the confidence in future assessments. It may also alert authorities to take action in order to avoid serious damage to ecosystems goods and services.

The EE method allows for the capture and inclusion of local and traditional knowledge and experience in the assessment process (Reed, 2008). The reporting agency mandated to organize an EE workshop has the option at the outset of inviting local experts from diverse backgrounds to participate (McBride and Burgman, 2012; Step 1 in Figure 2). Such experts could include representatives from indigenous groups, local artisanal fisherfolk, environmental groups or others whose knowledge and experience is otherwise not available (i.e. not published in reports or available from other sources). In the present study, local experts from the Norwegian Directorate of Fisheries (Fiskeridirektoratet), the Norwegian Fishermen’s Association (Fiskarlaget Sør) and from the Aust- and Vest-Agder County Governor’s Office participated in the workshop.

Workshop discussions contain a human dimension that includes personalities, cultural differences, deference to authoritative senior individuals and bias that can be introduced subconsciously by the facilitator (Burgman, 2005). These factors can, to some extent, be accounted for by appointing an independent facilitator to conduct the workshop discussions (Walls and Quigley, 2001).

The EE method can address the bias introduced from well-studied locations and their influence on assessing the condition of a larger area (the

so-called "boundary problem" in spatial analysis; Haining, 1993). The question here is the extent to which an observation at a specific location can be extrapolated to the surrounding area that has no natural boundaries. The EE method uses the 10 per cent best and 10 per cent worst area scenarios to address this bias. It is acknowledged that the latter may have the best available data (and highest confidence in scoring), whereas there may be very little data available for the former area (un-impacted by human activities).

Another factor that is important in planning an EE workshop is the selection of the spatial area to be considered by the experts. For example, in the case of the Australia State of the Environment (2011) report, the assessment was carried out using three workshops that covered four different biogeographic provinces. Different experts were invited to each of the workshops, reflecting the regional partitioning of the available expert knowledge. This factor is likely to apply in most regions of the global ocean and hence it is probably most reasonable to expect one workshop to focus on an area no larger than a single biogeographic province or large marine ecosystem (FAO, 2005).

An important consideration for the conduct of any state of the environment assessment is the availability of data. A major advantage of the EE method is that, provided that there are experts available with knowledge of the area under consideration, it can be applied in data-poor regions of the world. Such data-poor conditions occur in both developing (e.g. Sierra Leone; EPA, 2015) and developed countries (Australia; Australia State of the Environment, 2011), but building national SOME assessments in developing countries using the available, in-country knowledge base is a critical consideration. This was the experience of the United Nations World Ocean Assessment, which held a series of workshops to ascertain the levels of data and information available in various regions around the world (United Nations World Ocean Assessment, 2016). A consistent message received from the workshops was that, while there may be a lack of peer-reviewed publications backed by quantitative data sets, there are experts available with knowledge and experience relevant to the conduct of an SOME assessment. In short, the participation of developing countries in initiatives such as the United Nations World Ocean Assessment (2016) is dependent upon their ability to conduct their own SOME assessments. Approaches based on the analysis of experts' views (such as the EE method) may provide a solution.

The scientific credibility of any method is dependent upon its ability to produce results that are both consistent and repeatable. Assessment results are subject to peer review, which is the primary means of their scientific validation for consistency with what is known about the condition of the environment under investigation. There have been no studies comparing SOME assessments completed by the EE method to investigate their ability to reproduce a result using (for example) different, but comparable, experts. However, growing literature on testing the validity of EE-type assessments (e.g. Burgman, 2005; Dahlstrom et al., 2012; McBride et al., 2012) has provided numerous suggestions on ways to improve the outcome, such as by addressing the issues discussed above (expert bias, overconfidence, use of an independent facilitator, etc.).

5. Conclusions

The state of the environment in the Raet Park has been assessed using the expert elicitation (EE) method. Factors contributing to the successful completion of this assessment include the involvement of 20 experts with a broad range of experience and knowledge of the local marine park environment as well as its social and economic aspects. The experts' knowledge and experience is supplemented by a number of published reports and scientific papers, which document high degrees of confidence in the assessment of a number of factors. The web-based software developed by GRID-Arendal allows the experts to review the results of their assessment in real time, which also contributes to the quality of the final report and the speed at which it is produced. We conclude that the EE method is suitable for application on a local spatial level, to assess the environmental condition and trend of a marine protected area (marine park). While it may not provide quantitative information as would be provided by field surveys (collection of primary data), the method does provide managers with sufficient information to take decisions on whether or not to intervene in particular situations, while avoiding the added cost and length of time that field surveys require.

Several knowledge gaps have been identified based on the analysis. Firstly, there are insufficient data to comment on the condition of nine of the 17 habitats in the Raet Park that the IMR has mapped; the habitats are known to exist but information on their status is lacking. However, there is strong evidence that lobsters are overfished and their conservation could be strengthened through expanding existing no-take zones or establishing new ones within the park. Sugar kelp habitat has been damaged in the park by human activities and although its condition is thought to have stabilized in recent years, it requires ongoing monitoring to ensure that it continues towards recovery. Spatial information on species, ecological processes, physical and chemical processes and human pressures is insufficient in most cases to provide scores on the best and worst 10 per cent of areas. Thus, while the overall condition of the Raet Park environment is generally good, there are significant data gaps and management measures that warrant the authorities' attention.

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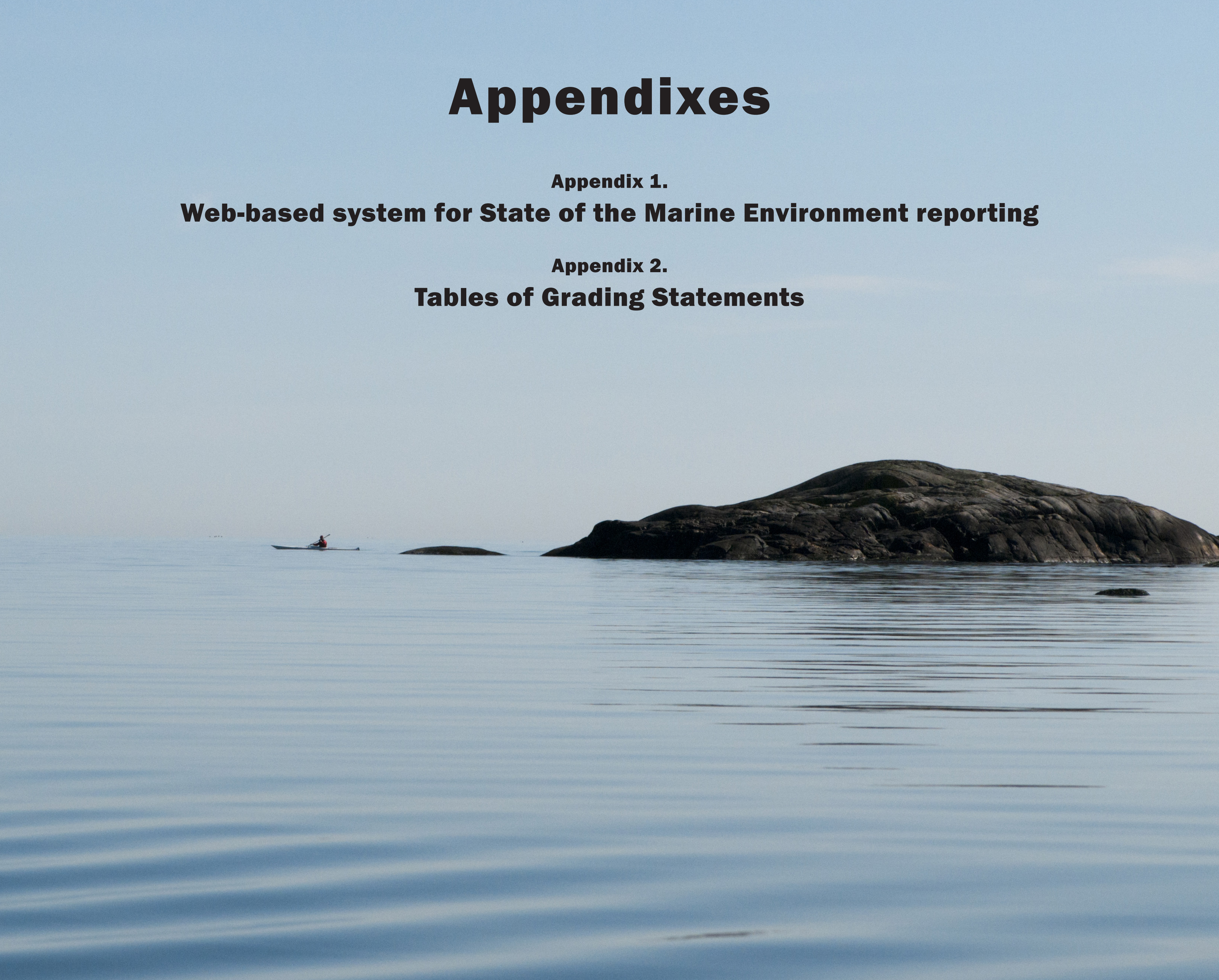
Appendixes

Appendix 1.
Web-based system for State of the Marine Environment reporting

Appendix 2.
Tables of Grading Statements



Appendix 1.
Web-based system for State of the Marine Environment reporting

GRID-Arendal has created a pilot, web-based system to capture and analyse scores produced during expert elicitation workshops: http://some.grida.no, with the following main features:

- A core set of marine environmental and socioeconomic parameters is included in the system. This set is based upon the United Nations World Ocean Assessment (WOA, 2016) chapters. The set of parameters can be easily adapted with relevant parameters to a country or region identified by experts.

- Identification and compilation of relevant data and information: the system allows the capture of relevant information sets. Important reference data sets and publications identified by the experts while developing the SOME reports can be added to the website, either as external links or uploaded to the website in PDF, Word or other formats.

- The website allows for the real-time capture and display of data and statistics (scores for parameters, confidence, risks) during the workshop.

- The website provides a template for the production of a State of the Marine Environment report. This outline is based upon the DPSIR system (Driving Forces-Pressures-States-Impacts-Responses), the WOA outline and other relevant report templates (e.g. Australia State of the Environment (SoE) report). The content and graphics can be exported and used as the basis for a national or regional SOME report or the contents can be adapted for use within other formats as required.

- The database allows direct correlation to the WOA outline, thereby permitting cross-referencing and combining assessment outcomes to optimize its contribution to the international effort.

- Another key aspect is that the diagrams and outputs produced by the website are designed for easy communication of the workshop results to policymakers and decision makers. The diagrams are simple, jargon-free and clearly communicate the main findings of the experts' judgments.

- The system allows contributing experts to be assigned different roles during the development process for SOME reports: main editors, contributors, reviewers, etc. Contributors can be made responsible for one or more chapters in the SOME outline. Draft versions of the report can be circulated to all participants to update and review the report and workshop outcomes, including recording key references and anchors that may have been overlooked.

Appendix 2.
Tables of Grading Statements

Table 1: *Grading statements for habitats, based on Ward (2011). Experts must consider the cumulative impacts of all pressures that may have impacted upon habitat condition (e.g. Baker and Harris, 2012).*

Habitats	Grading statements for habitats that occur in the state and/or region under consideration.
Very Good (7–8)	The habitat type is essentially structurally and functionally intact and able to support all dependent species.
Good (5–6)	There is some habitat loss or alteration in some small areas, leading to minimal degradation but no persistent substantial effects on populations of dependent species.
Poor (3–4)	There is habitat loss or alteration in a number of areas, leading to persistent substantial effects on populations of some dependent species.
Very Poor (1–2)	There is widespread habitat loss or alteration, leading to persistent substantial effects on many populations of dependent species.

Table 2: *Grading statements for species, based on Ward (2011). Experts must consider the cumulative impacts of all pressures that may have impacted upon the species' condition.*

Species	Grading statements for different species assessed, given what is best understood about their status and trends expressed in terms of populations and groups of species, including threatened, endangered or protected species.
Very Good (7–8)	Only a few, if any, species populations have declined as a result of human activities or declining environmental conditions.
Good (5–6)	Populations of a number of significant species but no species groups have declined significantly as a result of human activities or declining environmental conditions.
Poor (3–4)	Populations of many species or some species groups have declined significantly as a result of human activities or declining environmental conditions.
Very Poor (1–2)	Populations of a large number of species or species groups have declined significantly as a result of human activities or declining environmental conditions.

Table 3: *Grading statements for ecological processes, based on Ward (2011). Experts must consider the cumulative impacts of all pressures that may have impacted upon the condition of ecological processes.*

Ecological Processes	Grading statements for the main ecological processes, and effects of human activities.
Very Good (7–8)	There are no significant changes in ecological processes or ecosystem services as a result of human activities.
Good (5–6)	There are some significant changes in ecological processes as a result of human activities in some areas, but not to the extent that they are significantly affecting ecosystem functions.
Poor (3–4)	There are substantial changes in ecological processes as a result of human activities, and these are significantly affecting ecosystem functions in some areas.
Very Poor (1–2)	There are substantial changes in ecological processes across a wide area of the region as a result of human activities, and these are seriously affecting ecosystem functions in much of the region.

Table 4: *Grading statements for physical and chemical processes, based on Ward (2011). Experts must consider the cumulative impacts of all pressures that may have impacted upon the condition of physical and chemical processes.*

Physical and Chemical Processes	Grading statements for the main physical and chemical processes as modified by human activities.
Very Good (7–8)	There are no significant changes in physical or chemical processes or ecosystem services as a result of human activities.
Good (5–6)	There are some significant changes in physical or chemical processes as a result of human activities in some areas, but these are not to the extent that they are significantly affecting ecosystem functions.
Poor (3–4)	There are substantial changes in physical or chemical processes as a result of human activities, and these are significantly affecting ecosystem functions in some areas.
Very Poor (1–2)	There are substantial changes in physical or chemical processes across a wide area of the region as a result of human activities, and these are seriously affecting ecosystem functions in much of the region.

Table 5: *Grading statements for pests, introduced species, diseases and algal blooms, based on Ward (2011). Experts must consider the cumulative impacts of all pressures that may have impacted upon the condition of pests, introduced species, diseases and algal blooms.*

Pests, Introduced Species, Diseases and Algal Blooms	**Grading statements for pests, introduced species, diseases and algal blooms.**
Very Good (7–8)	The incidence and extent of diseases and algal blooms are at expected natural levels, there are insignificant occurrences or numbers of pests, and the numbers and abundance of introduced species is minimal.
Good (5–6)	Incidences of diseases or algal blooms occur occasionally above expected levels of occurrence or extent, and recovery is prompt, with minimal effect on ecosystem functions. Pests have been found, but there have been limited ecosystem impacts. The occurrence, distribution and abundance of introduced species are limited and have minimal impact on ecosystem functions.
Poor (3–4)	Incidences of disease or algal blooms occur regularly in some areas. Occurrences of pests require significant intervention or have significant effects on ecosystem functions. The occurrence, distribution and abundance of introduced species trigger management responses, or have resulted in significant impacts on ecosystem functions.
Very Poor (1–2)	Disease or algal blooms occur regularly across the region. Occurrences of pests or introduced species are uncontrolled in some areas, have displaced indigenous species and are seriously affecting ecosystem functions.

Table 6: *Grading statements for the environmental impact of marine-based industries.*

The Environmental Impact of Marine-based Industries	**Grading statements for the environmental impact of marine-based industries.**
Very Good (7–8) Low Pressure	This industry has caused no significant changes in the overall environment (condition of habitat, species, ecosystem processes or physical and chemical processes) within its footprint.
Good (5–6) Moderate Pressure	This industry has caused some significant changes in some components of the overall environment, but not to the extent that they are significantly affecting ecosystem functions.
Poor (3–4) Significant Pressure	This industry has caused substantial changes in many components of the overall environment, and these are significantly affecting ecosystem functions in some areas of its spatial footprint.
Very Poor (1–2) High Pressure	This industry has caused substantial changes in many components of the overall environment, and these are seriously affecting ecosystem functions across its spatial footprint.

Table 7: *Grading statements for the socioeconomic benefits that society receives from marine industries.*

Socioeconomic benefits	Grading statements for the socioeconomic benefits society receives from marine industries. This is the total benefit including employment, taxes, royalties and licence fees paid to the state, education and training, human health benefits and infrastructure (buildings, roads, etc.). It includes both the direct employment benefits as well as dependent and supporting industries.
Very Good (7–8) High benefits	The industry is mainly or wholly owned by national interests and is a major national employer, both through direct employment and supporting industries (indirect employment). The state receives significant taxes, royalties and/or licence fees and a significant portion of profits remain in the country. The industry exploits a sustainably managed renewable resource and contributes to one or more of: education and training programmes, human health and medical benefits and national infrastructure.
Good (5–6) Significant benefits	The industry is an important national employer, both through direct and indirect employment, and the state receives taxes, royalties and/or licence fees. The industry may contribute to education and training programmes, human health or medical benefits.
Poor (3–4) Some benefits	The industry is a minor employer both through direct and indirect employment and the state receives some taxes, royalties and/or licence fees. The industry is partly or mainly foreign-owned.
Very Poor (1–2) Few or no benefits	The industry is mainly or wholly foreign-owned and is not a nationally important employer, with most/all employment based overseas. The industry exploits a non-renewable resource (or an unsustainably managed renewable resource) and the state receives very little in taxes, royalties or licence fees from this industry.

Table 8: *Scores for likelihood that an event will occur.*

Likelihood – This is the probability of the impact occurring over a five-year or 50-year timescale, taking into account the effectiveness of present and recently implemented (unplanned) management arrangements and activities.	
Almost certain (score = 5)	Expected to occur often within five (50) years
Likely (score = 4)	Expected to occur at least once within five (50) years
Possible (score = 3)	Occurrence is possible within five (50) years
Unlikely (score = 2)	Occurrence is unlikely within five (50) years
Rare (score = 1)	Not expected to occur within five (50) years

Table 9: *Scores for the consequences or impact if an event were to occur.*

Consequence/Impact – This is the extent and severity of the expected impact, taking into account the effectiveness of present and recently implemented (not planned) management arrangements and activities.	
Catastrophic (Score = 5)	Impact will seriously affect the ecosystem in the region, disrupting a major ecosystem structure or function, and have recovery periods of more than 20 years (potentially irreversible).
Major (Score = 4)	Impact will seriously affect the ecosystem in the region, disrupting a major ecosystem structure or function, and have recovery periods of less than 20 years.
Moderate (Score = 3)	Impact will affect the ecosystem in the region, disrupting some aspects of an ecosystem structure or function, and have recovery periods of less than five years.
Minor (Score = 2)	Impact will be spatially very limited (<10 per cent of area) and will affect only minor components of the ecosystem in the region.
Negligible (Score = 1)	Impact will be spatially confined to a minor area (<5 per cent) and will not be able to be detected beyond that area.