Navigating future uncertainty in marine protected area governance: Lessons from the Scottish MPA network

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Abstract

As international pressure for marine protection has increased, Scotland has increased spatial protection through the development of a Marine Protected Area (MPA) network. Few MPA networks to date have included specific considerations of climate change in the design, monitoring or management of the network. The Scottish MPA network followed a feature-led approach to identify a series of MPAs across the Scottish marine area and incorporated the diverse views of many different stakeholders. This feature led approach has led to wide ranging opinions and understandings regarding the success of the MPA network. Translating ideas of success into a policy approach whilst also considering how climate change may affect these ideas of success is a complex challenge. This paper presents the results of a Delphi process that aimed to facilitate clear communication between academics, policy makers and stakeholders in order to identify specific climate change considerations applicable to the Scottish MPA network. This study engaged a group of academic and non-academic stakeholders to discuss potential options that could be translated into an operational process for management of the MPA network. The results of Delphi process discussion are presented with the output of a management matrix tool, which could aid in future decisions for MPA management under scenarios of climate change.

Key Words: climate change, Delphi technique, MPA management, marine protected area network, Scotland

1. Introduction

Marine ecosystems are facing a diverse range of threats, including climate change, prompting international efforts to safeguard marine biodiversity through the use of spatial management measures (Allison et al., 1998; Lubchenco et al., 2003; Chuenpagdee et al., 2013). Marine Protected Areas (MPAs) have been implemented as a conservation tool throughout the world, but their usefulness and effectiveness is strongly challenged by climate change (Harley et al., 2006; Andrello et al., 2015). Whilst MPAs cannot explicitly protect against climate change related disturbances (e.g. ocean acidification), MPAs can assist in sustaining biodiversity and ecosystem processes at regional and local scales (Levy and Ban, 2013). The reduction of other anthropogenic threats (e.g. overfishing) can minimise the synergistic impact of other stressors which may exacerbate detrimental changes to ecosystem health (Harley and Rogers-Bennett, 2004; Harley et al., 2006; Levy and Ban, 2013). The reduction of additional stressors could also contribute to increased ecosystem resilience in the face of climatic stress (see Bernhardt and Leslie, 2013). However, few MPA programmes have directly considered climate change in the design, management or monitoring of an MPA network (Hopkins et al., 2016a). Considering elements of design, management and monitoring that could enable an MPA network to perform effectively under scenarios of climate change, could also improve networks more generally.

Under international obligations, EU, UK and national targets (e.g. CBD, OSPAR), Scotland has developed an MPA network intended to protect marine biodiversity and contribute to the vision of a clean, healthy and productive marine environment (Scottish Government, 2011a). The implementation of the Scottish MPA network has been a complex process requiring the consideration of stakeholder values and perceptions, scientific evidence and political factors (Hopkins et al., 2016b). There is a need to facilitate clear communication between academics, policy makers and stakeholders to progress MPA policy delivery and ensure decisions are jointly formed and therefore acceptable to multiple parties (Pollnac et al., 2010). The Scottish Nature Conservation MPA network consists of 30 MPAs designated in 2014: 17 MPAs under the Marine (Scotland) Act 2010 in Scottish territorial waters and 13 MPAs under the Marine and Coastal Access Act 2009. Scottish Natural Heritage (SNH) and the Joint Nature Conservation Committee (JNCC) submitted formal advice to parliament following a series of stakeholder workshops.

The Scottish MPA network (including other types of protected area designation) covers approximately 20% of the Scottish sea area. The Scottish MPA network is intended to contribute to an OSPAR ecologically coherent network and is part of the Scottish Government's three pillar approach to conservation, which includes spatial protection, wider seas measures and species-specific protection and management measures (Scottish Government, 2011a). Together, the three-pillar approach is intended to contribute to the achievement of Good Environmental Status (GES) under the Marine Strategy Framework Directive (MSFD). Therefore, it is important to assess the contribution that the MPA network makes towards protecting marine biodiversity and the delivery of GES. Furthermore, with increasing pressure from climate change on marine biodiversity, an effective MPA network will be crucial in providing climate change resilience. We define resilience here as the ability of an ecosystem to experience disturbance without substantial biological change (Holling, 1973), a change that could result in an alternative state and loss of ecosystem function (Côté and Darling, 2010).

The Scottish MPA network was developed using a feature-based approach to site selection, whereby MPA sites were selected based on the “locations of habitats or species which are important, rare, threatened and/or representative of the range of features in the UK marine area” (Scottish Government, 2011b) termed Priority Marine Features (PMFs) (see Howson et al., 2012). It will be important to assess whether such a feature led approach is effective for selecting MPA sites that will remain resilient under climate change scenarios. Each Scottish MPA also has a Conservation Objective of either “conserve” or “recover” tying MPA management measures to the feature for which each site was designated. These objectives are vague and therefore difficult to measure under climate change scenarios where it may become unfeasible to achieve such an objective (Cliquet et al., 2009).

The aim of this study was to facilitate the identification of high level management options for Scottish MPA network in the context of potential climate change scenarios prior to the development of site specific management options. There are few examples of high level

MPA decision making, for example, under what circumstances should a new MPA be designated, or an MPA that is no longer effective or successful, de-designated. This study aimed to explore these options in the context of climate change, answering the following research questions:

Are there differences in the perceptions of MPA success between different stakeholder groups?

How can we effectively protect marine ecosystems under climate change scenarios?

What are feasible options for including climate change specific management and monitoring strategies?

2. Materials and methods

A Delphi method was devised in this study to elicit perceptions and options for climate change management scenarios. The Delphi method is becoming more frequently applied to conservation and biodiversity management issues due to their complex nature, involving a range of stakeholders and trade-offs (Hess and King, 2002; O'Neill et al., 2008; Gobbi et al., 2012). The Delphi method is a flexible methodology suitable for complex policy problems, particularly where there is significant uncertainty, lack of historical precedent and especially in situations where information is limited or conflicting (Mukherjee et al., 2015). Questions are posed and responses to those questions exchanged usually anonymously with other participations via a process facilitator and is an effective way for a group to deal with a complex issue either reaching consensus or identifying convergence of opinion (Linstone and Turoff, 2002; Hsu and Sandford, 2007). The benefit of the reflective deliberation of the Delphi method may also be the development of more creative solutions by groups of people (Reed, 2008). The Delphi method employed here did not seek consensus, seeking instead an improvement in understanding and clarification of the issue, therefore sharing similarities with Policy Delphi. As Rowe and Wright (2011) suggest, the most interesting and important issues often emerge where consensus is not evident.

MPA processes involve a complex range of stakeholders from various economic, social and environmental interest groups. As such, the panel was carefully selected to apply their knowledge and experience to the study issue and to reflect the diversity of stakeholders involved in the MPA process. Following Glass et al. (2013) a stakeholder map was created to identify a matrix of organisations and stakeholder interest groups related to the Scottish MPA process. Potential participants were selected if they met one or more of the following criteria: active role in the Scottish MPA process, relevant experience in other UK MPA processes, member of a representative body, and academically relevant research to MPAs and/or marine climate change. The size of the panel is not a critical feature of the Delphi method as participants are purposefully rather than randomly selected and reliable results can be obtained by choosing participants using strict inclusion criteria (Akins et al., 2005).

2.1. Progression through rounds

The Delphi study began in January 2014 and consisted of two emailed questionnaires and a final focus group round that concluded the participant input process in September 2014. The focus group provided the participants with an opportunity for face to face interaction, encouraging motivation to remain engaged in the process. The participants had an adequate history of communication through the Scottish MPA process stakeholder workshops. Additionally, the use of the focus group further complemented the Delphi technique by emphasising the synergy of a group for producing ideas over and above individual contributions (Krueger and Casey, 2009). Results presented in this paper reflect final outcomes from the Delphi method, following the three rounds (Fig. 1.). Round One and Two identified potential management options and discussed the feasibility of these options. Recognising the feature-based approach to designation of the Scottish MPAs, the participants of the focus group were presented with a series of feature-based scenarios whereby the abundance or presence of a feature changed, to explore which possible management options were available and under which circumstances these were acceptable and feasible. The scenarios focused on the high level management options suggested by participants in previous rounds, rather than specific management relating to activities (e.g. types of gear restriction).

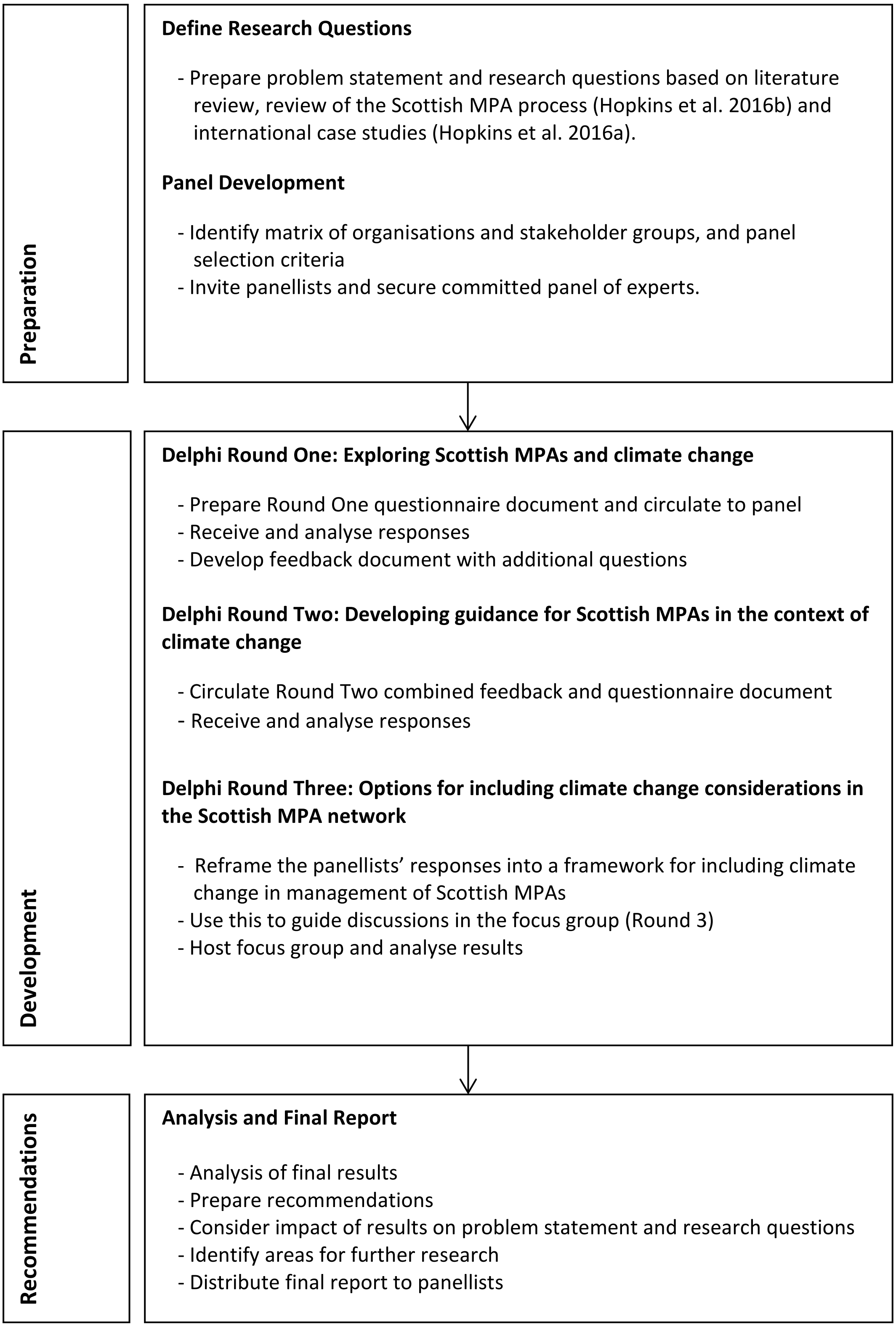

Figure 1. Overview of the Delphi process to identify management options under climate change scenarios for the Scottish MPA network. (Adapted from Lemieux and Scott (2011)).

2.2. Composition of the panel

Upon acceptance respondents from similar organisations nominated one person to speak on behalf of the interest group and this person became the point of contact (Participants 1, 2 and 10). Reasons given for the collective input included the already heavy investment of relevant organisations involved in the on-going MPA designation process and reshuffling of employees within the relevant organisations to different policy areas. Six participants completed the Round One questionnaire and four participants responded to the Round Two questionnaire (Participants 1 and 8 did not complete). Whilst, this resulted in a low panel number for Round Two and a loss of two perspectives (policy maker and practitioner/professional), the information provided by the remaining four panellists was detailed and illustrated in-depth thinking concerning the feedback (from Round One) and resultant questions. Additionally, there was some overlap in the remaining participants with the non-respondents in terms of experience and background (i.e. a practitioner/professional and policy maker responded to Round Two). To counter-act the lower response rate of Round Two further action was taken: i) renewed efforts were made to contact the participants to encourage them to respond to the questionnaire and subsequent round; ii) additional potential participants from the stakeholder map having experience and knowledge in the research topic were invited to participate in the Delphi focus group. Subsequently, Participant 8 confirmed their acceptance of the invitation to attend the focus group with an additional four participants. The focus group was attended by ten participants (seven of whom had provided input into the preceding questionnaires (Table 1).

Table 1. Summary of participant characteristics and identification method.

Sub-Focus Group	Participant Number[1]	Organisation	(Group)	Identification Method
-	1*	Marine Scotland	Policy Makers and decision makers	Stakeholder Workshop Referral; reputation
-	2**	Scottish Environment Link	Representative Body; NGO	Stakeholder Workshop; reputation
1	3	Royal Society for the Protection of Birds (RSPB)	Representative Body; NGO	Stakeholder Workshop; reputation
1	4	Scottish Fishermen's Federation (SFF)	Representative Body	Stakeholder Workshop; referral
1	5†	Visit Scotland		Referral
1	6	Marine Conservation Society (MCS)	Representative Body; NGO	Stakeholder Workshop; reputation
1	7†	Sniffer (Registered charity)	Practitioner and Professional	Referral
2	8***	British Sub Aqua Club (BSAC), Academic	Practitioner and Professional	Referral; reputation
2	9	RSPB	Representative Body; NGO	Stakeholder Workshop; reputation
2	10	Scottish Natural Heritage (SNH)	Policy Makers and decision makers	Grey literature; Referral; reputation
2	11†	Academic	Practitioner and Professional	Referral; academic publications
2	12	Academic	Practitioner and Professional	Referral; academic publications

*Participant completed Round 1 questionnaire but did not attend focus group
** Participant completed questionnaires as collective (individual NGO members (RSPB and MCS) attended focus group)
*** Participant completed Round 1 questionnaire and attended focus group
†Participant attended focus group only
[1]The numbers used to list participants in the above table correspond to those used subsequently in this paper

2.3. Data collection and analysis

The questionnaire responses were imported into QSR International NVivo software (QSR International Pty Ltd, 2010) facilitating organisation, coding and retrieval of the data (Bazeley and Jackson, 2013). Analysis of questionnaire data followed a thematic content analysis to identify salient issues and key elements of the dataset (Green and Thorogood, 2014). Data analysis broadly followed the steps suggested by Braun and Clarke (2006). Each questionnaire was firstly read through in detail with the addition of analytic notes and initial ideas regarding emerging themes. The data was then coded, grouping similar data segments (e.g. a particular sentence) together under each emergent code. Similar codes were combined under key themes that illustrated the perceptions of the participants for each question. All focus group sessions were audio-recorded and field notes were written by the researcher during and after the focus group. Additional field notes collected by the two facilitators, and flip charts produced by the participants were reviewed in the analysis process. The sessions were fully transcribed using NVivo software. Inductive open coding was used to generate codes and categories in the analysis providing a rich, in-depth and grounded account of the data (Corbin and Strauss, 2015). The results were interpreted by relating the categories to the research questions and theoretical ideas underpinning the research.

3. Results

3.1. Management success in the context of climate change

There were conflicting opinions as to whether the conservation objectives set for the MPA sites (conserve or recover for designated features), were ambitious enough in a climate change context. Opposing views were: MPAs should address wider ecological processes, improving the biodiversity of the designated site but also having wider benefits for the marine environment; and MPAs were designated for specific purposes (to conserve or recover specific species and habitats), therefore too high expectations were placed on what the network could successfully achieve.

"If the conservation objectives of an individual MPA are achieved then it could be argued that the MPA has been successful but you would maybe want to achieve more in terms of helping to increase resilience in the marine environment to climate change and other pressures." **Participant 1.**

The difference between success of a single MPA site and the success of the network was highlighted, raising the question of how success of the network may be achieved if there are different objectives at a site and network level. Participants felt further work was needed to define ecological coherence and even a working definition of what is considered an MPA network in the context of the Scottish MPA sites.

"It is also not clear to what extent the network will be "ecologically coherent" given that it doesn't seem to have been designed with that in mind, but rather to protect a series of key (but at times isolated) features and species." **Participant 11.**

There was concern that the network had not been designed to consider connectivity and therefore that success in terms of realising wider ecosystem health may not be accomplished. Participants recognised that enhancing ecosystem health would be important given the additional stress that climate change would likely have on the marine environment and that the network should not just keep the "status quo" by protecting residual populations. The concept of "status quo" was linked to ideas of dynamism in the marine environment, recognising that features may change in the face of climate change, i.e. it would not be possible to protect MPAs from sea temperature changes, as these wider processes would not recognise the site boundaries. Disagreement was evident; one participant was concerned with the approach recommended to protect areas for wider ecological processes.

This view reflects the feature based approach for the network yet appears to contradict with the original Scottish vision for the MPA network. The most widely mentioned factor for success was the ability of the management (as a result of the legislation underpinning the designations recognising climate change) to be adaptable. Participants were divided as to whether planned management and monitoring (at the point of survey) would account for climate change.

"The planned management of MPAs in the Scottish MPA network is being driven by the sensitivity of the proposed protected features to pressures arising from activities known to be taking place within the sites. Climate change scenarios really aren't informing management at this stage." **Participant 1.**

Overall, there was a dichotomy in participant opinion for a successful network: the protection of specific features and habitats of conservation interest versus wider improvement of the marine environment as a result of the protection and whether these are mutually achievable.

3.2. Management scenarios

The preceding questionnaires identified management options and discussed the feasibility of these options. These were reframed by the researchers into a matrix of high-level management actions in combination with possible climate change scenarios. For example, a feature is no longer present within the MPA, which possible management option is suitable/acceptable under this scenario. This approach was based on the discussions regarding feasible management options, and recognised the feature-based approach to designation of the Scottish MPAs. The participants were presented with a series of feature-based scenarios whereby the abundance or presence of the feature changed and each scenario was discussed by participants with the aim of deciding which possible management actions were available and under which circumstances these were acceptable and feasible. The matrix focused on the high level options suggested by participants in previous rounds, rather than specific management relating to activities (e.g. types of gear restriction). Sites with multiple designated features present were not considered, however, participants were given the option of considering wider biodiversity and whether this would affect their choice of management action.

The management scenarios matrix (Table 2) summarises the possible management options (from participant discussion) at a site and network level under five different scenarios of change for the MPA feature at the level of an individual MPA: i) the feature is no longer present ii) feature is decreasing iii) feature is stable/demonstrating no overall trend iv) feature is improving and v) the feature is recovered.1[1] In terms of the matrix, the above change scenarios are in absolute terms (i.e. not compared to trends in other times and places). The scenarios are also further sub-categorised for site integrity (i.e. wider biodiversity of the site in addition to the status of the feature for which the site is designated) and how the MPA feature is performing at a network level i.e. whether it is stable/declining/increasing across the network. For all scenarios, participants suggested a "balanced review" would be required, and evidence to support decisions before deciding upon any action, taking into account the whole network at appropriate timescales, but did not elaborate on what would constitute a balanced review or what evidence would be needed. Participants suggested that a network review would be useful for a "recalibration", identifying if any gaps in feature protection were present, or if broader network scale factors (i.e. climate change) were a cause of change. However, it was recognised that identifying causal factors was often incredibly difficult, highlighting the need for a strong monitoring programme. Therefore, some participants maintained a "precautionary" approach to management (i.e. stricter management measures); "precautionary" was also applied in reference to changing management, (i.e. ensuring a strong evidence base before changing current management measures).

Participants felt that a review of management measures would therefore be needed to answer whether the current management had fully removed the pressure. There was also recognition from participants that the dynamic nature of the marine environment would need to be reflected in adaptive management.

Control areas were mentioned in reference to understanding changes and linked to resilience. The option of a new MPA (or moving an MPA) was linked to recovering net loss of

[1] Researchers used the term "recovered" in reference to the draft definitions of MPA conservation objectives of either "conserve" or "recover" (Scottish Government, 2012). At the time of the research there was no quantitative definition or target of "recover" for the individual features.

a species where conditions were more favourable, or where suitable climatic conditions still prevailed. A more controversial option (from the participants) was MPA expansion, although mentioned in previous rounds, it was suggested that to expand the area a big change in policy would be needed as the boundaries of a site are tightly drawn around the feature of interest and legislatively implemented.

Problems with a feature based approach in a climate change context were identified by the researchers from the participant discussion; a summary of participant discussion and researcher comments around these problems is provided in Table 3.

Table 2. Summary Matrix of Management Options: Condition of MPA features under different scenarios of change

MPA feature Scenario at a site level[1]	Site Integrity[2]	MPA feature at a network level	Possible Management Actions (from participant discussion)	Decision Making Process (from participant discussion)
No Longer Present	Low quality	Still present	1. New MPA/Move MPA (Look to establish another MPA for the feature) Designate a new alternative area which may succeed, e.g. within new climatic window of feature.	- Question whether the current management actions are/were appropriate - Is there an alternative feature within the MPA? - Would maintaining this MPA fill a gap in network wide protection?
	Low/high quality	Still present	2. Reduce pressures in other MPAs. Look at other sites across the network where the PMF is still present within its climate window and reduce other stressors.	
	Low quality	Still present/no longer present across the network	3. De-designate the MPA[3] Option to give up on an area that has failed.	
	High quality site for biodiversity/other features	Still present/no longer present across the network	4. "Rebadge" the MPA (Look to designate the current site for another feature).	
Feature Decreasing	Low/high quality	Stable/Declining	1. Reduce pressures on PMF (further restriction to full ban on damaging activities).	- Identify the causes of a decline - Look to recover net loss of the feature across the network
	Low/High quality	Stable/Declining	2. Expand the area of the MPA	
	Low quality	Declining across the network	3. New MPA/Move MPA (Look to establish another MPA for the feature)	
Feature Stable	Low/High quality	Stable	1. Maintain current management measures	- Continue monitoring
Feature Improving	High quality site for feature	Stable across network/Feature common across network	1. Maintain current management measures	- Review pressures across the network - Is there clear evidence of improvement? E.g. greater extent, higher biodiversity, better age structure
	High quality for feature	Declining across the network	2. Expand the area of the MPA	
Feature Recovered	High quality for feature	Feature common across network	2. Review management of feature in other sites where it was not present previously	- Need for substantial evidence to reduce or change management

	High quality site for feature, biodiversity and other features	Feature common across network	3. Reduce or change management e.g. is there an option for sustainable use	- Is there clear evidence that it was the management of an activity that led to that improvement? - Is there clear evidence of improvement? E.g. greater extent, higher biodiversity, better age structure

[1]Change scenarios are in absolute terms (i.e. not compared to trends in other times and places).

[2]Site Integrity: Quality of the site for wider biodiversity in addition to the status of the feature for which the site is designated. This was summarised as a qualitative statement of either “low quality” or “high quality”. Site integrity was mentioned by participants in reference to site condition monitoring for other nature conservation sites (i.e. SPAs and SACs) and therefore could be of future relevance to the MPA sites, whilst not referenced in MPA objectives.

[3]De-designate MPA: There is a provision to de-designate an MPA under the Marine Act (Scotland) 2010.

Table 3. Summary of participant discussion around problems of a feature based approach in a climate change context

Researcher identified Problem from participant discussion	Participant Comments	Climate change scenario	Researcher Comments
Success judged on a single feature	Success of MPA will be dependent on state of that feature irrespective of wider biological health	Feature declines or is absent from site results in site viewed as failure irrespective of potential wider site improvement.	*Conceptually linked to valuation of marine biodiversity.* *Conflict between feature level objectives, wider pressures and an ecosystem or network level view of success*
MPA Management around a particular feature	Feature based management does not account for buffer zones or an ecosystem approach. Damaging activity is not precluded from the entire site, MPA is fragmented into various zones of management. Consequential protection of MPA designation is neglected.	An ecosystem approach required for climate change resilience at a network level is not considered. Wider biodiversity resilience to climate change impacts is not considered. Recovery (range expansion) of species and habitats is unlikely if management is tied to presence.	*Conflict between feature level objectives, wider pressures and an ecosystem or network level view of success*
"Rebadging" an MPA	A feature, for which the MPA is designated, is lost from the site. Potential for the site to be rebadged/repurposed for another feature.	If a feature is lost and you did not repurpose the MPA, you could lose consequential protection or any improvement in ecosystem health that resulted as a reduction in pressures. Secondly, there may be circumstances where data has improved and led to the identification of other Priority Marine Features (PMFs) or vulnerable species that could benefit from protection. Keep the site for monitoring purposes- resources dedicated	*Important that sites be retained for the right reasons which would require a network level review and stakeholder-determined reasons.* *There was a suggestion that it may be appropriate to look for a new area, although de-designation was seen as a last resort (species may not completely disappear or may have an opportunity to re-establish), but an option that should remain in the "management toolbox".* *Strong industry concerns in rebadging an MPA due to perceived lack of justification.* *A logical response from the MPA designation process would be to de-designate an MPA if it has not achieved its management objective (i.e conserve*

			feature). By retaining the MPA for other reasons than the specific feature designation could be seen as "moving goalposts" by changing the rationale behind designation. *However, there could be a trend towards loss of protection if failing MPAs are removed without seeking to understand why they are failing and seeking to rectify.* *Linked to the appropriate allocation of resources*
Features are not self-recruiting	Sites are not designed using connectivity principles.	Network is not designed as an ecologically coherent one and therefore does not consider potential climate change impacts	*Perceived limited consideration of connectivity across the network. Echoes concerns from MPA process stakeholder workshops*
Ecosystem health	A species cannot exist in isolation of its ecosystem. Lack of consideration for wider ecosystem health.	Network is not designed as an ecologically coherent one which takes into account wider ecosystem health and therefore does not consider potential climate change impacts	*Linked to the lack of connectivity principles across the site.*
Precautionary approach	Proposed management* is not optimal (or precautionary) and areas will be under protected. Considering wider ecosystem function and buffer zones of management and concern for whether the selection of features looked at richly biodiverse sites,	To ensure climate change resilience, effective management would be required.	*Effective management was considered by some participants as areas of strict protection surrounded by buffer zones*
Climate change not considered	Would more MPAs with features that are sensitive to climate change would have been established if climate change had been considered at the beginning of the process. Key features not considered in terms of their vulnerability to climate change	Under scenarios of loss, concerns were raised that if the success or quality of the site is to be judged solely on the status of the feature, and a site were designated for a climate sensitive species (e.g. maerl) which if declined or was lost from the site, the whole site would effectively be redundant. Therefore, it may be possible that a number of sites are potentially vulnerable to the feature being lost; the approach does not account for how assemblages of species in MPA sites may change under climate change scenarios.	*Some participants were reluctant to have the MPAs broadened, stating that they should be justified.*

		Suggested that sites identified for a specific habitat or biotope are unlikely to lose the whole interest under scenarios of decline. One solution proposed was to widen the designation of the site to incorporate more habitats and features	

*Proposed Management: At the time of study management measures for the MPA sites were not in place

4. Discussion

Views of MPA success are likely to change under climate change scenarios (Hopkins et al., 2016a); this increases the complexity of applying legal definitions of success, which may become redundant under such scenarios. This study demonstrates the large fragmentation of opinion in what constitutes success even in the absence of considering climate change. As the discussion progressed from questionnaires to the focus group, the agreement of success in abstract principles broke down in the face of operational realities. A fundamental split was evident between participants sympathetic to the provision for sustainable use within the MPA network, and those participants stating that the MPA network should be primarily for conservation, enhancement of the wider marine environment and should contribute to climate change resilience. The different perceptions of MPA success influenced the subsequent discussions of management scenarios; whether participants felt the MPA network should strive for the minimum protection of species and habitats (features) versus MPAs enhancing the wider marine environment.

In the context of the Scottish feature-led MPA process, the approach to management resembles a discriminating approach using a feature sensitivity tool (FEAST),[2] which analyses the sensitivity of a designated feature to different types of human activity. Management measures based on this sensitivity may not be required across the entirety of the site if the feature is not present across the whole of the site. However, elsewhere there has been a move away from a species-by-species management towards broader ecosystem level strategies (Jentoft et al., 2007). By focusing management measures on one feature or species, impacts on other species (which may be of high ecological importance) are effectively ignored. Better protection of MPA features could be achieved by not only managing the direct impacts (i.e. habitat destruction) but also by considering the wider factors that influence their health (e.g. water quality, prey availability and trophic links). A review of scientific knowledge and international perceptions that informed the development of this study (Hopkins et al., 2016a) suggest management and protection should account for wider ecosystem links and concepts of resilience in the face of a large amount of uncertainty from climate change.

Participants noted that for MPAs to be successful under future scenarios of climate change, flexibility and adaptation were needed. However, although adaptive management is needed for climate change resilient MPAs (Davies et al., 2016; Hopkins et al., 2016a), there are few examples in practice. The importance of monitoring to inform adaptive management was noted whilst discussing

[2]http://www.marine.scotland.gov.uk/FEAST/.

the scenarios to clearly evaluate the effect of protection and to discern the impacts of climate change. Proposed options for adaptively managing MPAs including: flexible boundaries, buffer zones of management, and temporary MPAs that track ecosystem processes or features were deemed far from a practical reality for MPAs at present. The iterative nature of the Delphi method highlighted the difference between proposing options and subsequently using these in a practical scenario. For example, changing MPA boundaries was proposed as an option in the questionnaire rounds, yet when confronted with implementing this option for a range expansion (for example), participants were reluctant to use boundary changes. Changing MPA boundaries was regarded by the environmental sector as too fluid a measure to provide effective long term protection, whilst the fishing sector were concerned that it would lead to long term financial uncertainty. Therefore, whilst most actors within the MPA process advocate adaptive management, it remains difficult to define how this will work in a practical sense.

The success of adaptive management is highly dependent on strong monitoring programmes that are consistent and well-funded (Mee et al., 2008) and the policy context. MPAs are likely to be implemented in the absence of high quality baseline information (Sale et al., 2005) and with a large uncertainty regarding how climate change will affect MPAs. Therefore, as more knowledge becomes available through targeted research and monitoring, adaptive management is a necessary mechanism for incorporating new information and refining management with regards to marine protection (Mee et al., 2008; McDonald and Styles, 2014). Participants highlighted their concerns that the monitoring task for the MPA network was overwhelming, both in terms of the scale of the information needed to be able to confidently state that the network was achieving its aims, and in terms of the amount of resources needed to monitor both at a site and network level. Whilst the political framework is in place for the Scottish network to be adapted in light of new knowledge via the network review process there is also the requirement of political will in order to implement suitable responses (Mee et al., 2008) and robust mechanisms that ensure action is taken in light of new information, rather than a continuation of monitoring.

Participants were concerned that the Scottish MPA network had not been designed to protect ecosystem function and wider biodiversity. MPA networks designed for protecting biodiversity are likely to be important in preserving ecological functioning and therefore contributing to ecosystem resilience (Steneck et al., 2002). A network consisting of strictly protected areas with no intense anthropogenic stressors (e.g. fishing) and that incorporate consideration of ecosystem function are likely to be the most resilient to climate change (Harley et al., 2006; Brock et al., 2012; Micheli et al., 2012). The feature based approach used in Scotland is therefore concerning because without a coherent, connected MPA network, it is unlikely to be resilient to the impacts of climate change (Olds et al., 2012; Magris et al., 2014; Andrello et al., 2015). The approach taken by other countries (e.g. Australia) has been to incorporate multi-use at a network-scale but with a core of strictly protected no-take areas. Single MPAs that are small and not strictly protected, could be considered a false economy as larger well protected MPAs may be less costly in terms of reduced fisheries revenue by increasing the likelihood of spillover, stock recovery and a reduction in the variation of stock levels. However, fishers may not perceive the risk buffering capacity of larger MPAs sufficient to offset the value of foregone harvesting (Carter, 2003). Larger well protected MPAs may be less prone to sudden and unpredictable change (Edgar et al., 2014) and are likely easier to manage, requiring less adaptive management strategies and less detailed long term monitoring. However, at a network scale, there is potential for a portfolio of MPA design, with a range of protection from strict protection/no-take to multiple use. There is a useful opportunity for investigating varying levels of protection across the network, in the recently designated Fair Isle Demonstration and Research MPA as it is specifically targeted toward researching sustainable marine management approaches (FIMETI, 2015).

The restoration of marine habitats as outlined in the Marine Strategy Framework Directive (MSFD) and OSPAR guidelines, and a possible site level objective for an MPA feature in the Scottish MPA process recognises the need to increase resilience in degraded ecosystems. Whilst there are strong political foundations for restoration, these do not address the scientific (and socio-political) difficulties (Hopkins et al., 2016b). The use of feature presence is less ambiguous politically when compared to identifying and measuring overall ecosystem health. There are also technical uncertainties over whether a habitat will recover, how long it will take and non-linear recovery trajectories (Mee et al., 2008). Alternative stable states of an ecosystem may exist which make restoration attempts (to restore the ecosystem to the previous desirable state) unfeasible, impractical or too expensive (Hughes et al., 2005; Selkoe et al., 2015). The concept of shifting baselines (see Pauly (1995)) needs to be considered with regards to the desirable state of the ecosystem that the MPA should achieve. Suggestions from participants that qualitative discussions may need to occur to decide what past ecosystems looked like, echoed recommendations by Campbell et al. (2009) that marine restoration will need to explicitly recognise value laden judgements inherent in the decision context (Mee et al., 2008; Campbell et al., 2009). These value-laden judgements also extend into judgements of what future ecosystems will look like under climate change (as suggested in Hopkins et al., 2016a; b); reference states in this context are particularly contentious in marine systems (Mee et al., 2008).

Ecosystem Based Management (EBM) may provide a solution by integrating conservation with spatial ecology and ecosystem functioning. EBM focuses on the protection of multiple species, ecosystem processes and societal values, taking into account the wider effects of human use on the environment (Mee et al., 2008; Campbell et al., 2009; Olds et al., 2012). However, the data requirements for this and the current political landscape may mean that EBM approaches are unlikely to be implemented in the short term. The use of EBM as a solution was also not resolved in this study and remained part of the split in perceptions of whether the wider environment should be considered within the MPA designations. If EBM approaches are unfeasible at present, and feature-led approaches are inappropriate for climate change, management decisions need to be taken in light of data from reference sites and baseline for changes without the confounding influence of controllable (at least to some degree) or restrictable human stressors (e.g. fishing, dredging, development etc.). Without reference sites, "expert judgement" and human perceptions of change are used to make management decisions (Mee et al., 2008). As perceptions of quality can shift over each generation (Pauly, 1995) with each generation having its own reference state for what is high or "good" quality, these perceptions of quality may decrease as generally society becomes used to a lower level (Mee et al., 2008). Subjective management decisions are unlikely to be accurate and reference states of quality imply judgements of what is "'good'' or ''bad'' about the natural environment (Mee et al., 2008). The development of the MPA network is therefore recommended as a practical solution, but should include the implementation of strictly protected reference sites to allow more objective assessments of ecosystem health to be made (Mee et al., 2008) and importantly to increase resilience for climate change impacted species and habitats across the wider network.

5. Conclusions

The use of the Delphi method in this study enabled the researchers to include both stakeholders and decision makers to explore climate change adaptation options tailored to the Scottish MPA network. Continued dialogue between stakeholders, decision makers and scientists will be necessary to monitor, review and adaptively manage the MPA network in the context of climate change. The management framework presented here is intended to support the decision making process, recognising that some of the adaptation options may not be feasible or appropriate in a future context, and any decision should be made in response to new information and with consultation.

Over the course of the iterative process, a fundamental split between the perceptions of different stakeholder groups became evident. Those stakeholders, sympathetic to the provision of sustainable use (i.e the fishing sector representative) were supportive of the feature approach to conservation which underpins MPA designation in Scotland. Conversely, other stakeholders felt conservation through MPAs should contribute to wider ecosystem health requiring consideration of ecosystem links in the application of management. The process indicated that this difference in perception may be intractable between the two groups even within a carefully designed MPA process. The Scottish MPA process designated MPAs with an evidence base (feature presence and impact sensitivity) yet also specifies aiming to enhance ecosystem health and contribute to an ecologically coherent network but without a mechanism for Ecosystem Based Management (EBM) or a clear strategic ecosystem level vision. Proposed feasible options for including climate change specific management and monitoring strategies as a result of this study include the use of experimental reference areas (e.g. Fair Isle MPA). These areas could be used to monitor the impact of climate change on MPA species and habitats and the effect of varying levels of protection across the network on climate change resilience. Marine reserves are at this point considered politically unfeasible with some stakeholders, and the use of EBM as a solution appears unresolved.

From a scientific perspective strictly protected marine reserves are thought to be more resilient to climate change and reference areas will be critical to understand climate change impacts and effects supported by monitoring over medium to long-term timescales. Developing scenarios for MPAs under climate change is a useful exercise in developing potential management options and aiding decision making. For the Scottish MPA network, a key recommendation would be to develop research regarding how the MPA network at various scales will be affected by climate change, and use the outputs from this study to guide decisions regarding MPA management.

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