ASSESSING THE THEORETICAL EFFECTIVENESS OF MARINE PROTECTED AREA NETWORKS FOR HIGHLY MIGRATORY PELAGIC SPECIES IN A CONTEXT OF CLIMATE CHANGE:

THE IMPLICATIONS OF CONCEPTUAL AMBIGUITY & INCONSISTENCY

by

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ABSTRACT

As a result of increasing human pressures and global climate change, many populations of migratory species are facing wide scale population declines. In response, biodiversity conservation efforts have been directed at this suite of species in an attempt to stem such declines and promote population recovery. While research has proposed that networks of marine protected areas may have the potential to contribute to the conservation of migratory pelagics, MPA managers, planners and scholars possess diverse perspectives on such potential. This study synthesizes the state of knowledge depicted within the current scientific literature (2000-2018) as well as conveyed through expert interviews with regard to the utility of MPA networks for migratory pelagics. Results indicate that while networks of MPAs have the potential to provide effective conservation, and that a high level of agreement exists as to the important design and management components of effective MPA networks for migratory pelagics, three conceptual challenges require attention: (1) the lack of distinction between MPA 'networks' and MPA 'systems'; (2) uncertainty regarding what constitutes an 'MPA'; and, (3) how to incorporate dynamic approaches into MPA networks. As efforts to establish networks of MPAs continue to progress globally, and as work continues on a United Nations Biodiversity Beyond National Jurisdiction (BBNJ) instrument, it is essential that such challenges are thoroughly addressed.

LIST OF ABBREVIATIONS USED

ABNJ	Areas beyond national jurisdiction
BBNJ	Biodiversity beyond national jurisdiction
CBD	Convention on Biological Diversity
CCA	Connectivity conservation area
CMS	Convention on Migratory Species
DFO	Department of Fisheries and Oceans
EEZ	Exclusive economic zone
IUCN	The International Union for the Conservation of Nature
IUCN-WCPA	The International Union for the Conservation of Nature – World Commission on Protected Areas
MPA	Marine protected area
OEABCMs	Other effective area-based conservation measure
PA	Protected Area
SAC	Special Area of Conservation
WWF	World Wildlife Fund

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CHAPTER 1: INTRODUCTION

1.1 PROBLEM STATEMENT

Pelagic species are so named because they inhabit the pelagic zone, the area of the ocean encompassing everything from the surface of the ocean to a depth of 200m (Moyle & Cech, 2004). These species generally move long distances in search of food or in response to changes in their habitats, and thus fall within the category of highly migratory species (Moyle & Cech, 2004). In general, these species have a wide geographic distribution, both within and outside countries' 200-mile exclusive economic zones, and typically engage in significant annual migrations for feeding or reproductive purposes. As pelagic species, they live predominately in the open ocean, although they may spend part of their life cycle in nearshore coastal waters and may nest on land (Pacific Fishery Management Council, 2014).

Migratory marine species are threatened by entanglement, by-catch, over-fishing, noise and chemical pollution, ship strikes, habitat destruction or degradation, and global climate change (CMS, 2008). Climate change is likely to have several negative impacts on marine migratory species through loss of habitat, reduced ocean productivity, shifts in location of prey and habitat due to changes in ocean currents and sea surface temperature, or direct mortality (CMS, 2008; Lascelles et al., 2014). As a result of such threats, the populations of several charismatic migratory pelagic species, such as sharks, sea turtles, and marine mammals, are facing wide-scale population declines (Lascelles et al., 2014, Schipper et al., 2008). Such declines can exacerbate the threats facing marine ecosystems due to the important roles of large consumers in maintaining and regulating the structure and function of habitats (Ripple et al. 2014; Scott et al., 2012; Estes et al. 2011).

Unsurprisingly, therefore, migratory pelagics have been the focus of a significant portion of biodiversity conservation efforts worldwide.

In the past two decades marine protected areas (MPAs) have gained considerable favour as a spatial management strategy to address the rising anthropogenic pressures facing marine species and their habitats, and have been recognized in several international marine conservation initiatives such as the Convention on Biological Diversity (CBD), the Strategic Plan for Biodiversity, and its related Aichi Targets (Notarbartolo Di-Sciara, et al 2008; CBD, 2016; MacKinnon et al., 2015). In response to the spatial target of at least 10% of the global ocean to be protected (Aichi target 11), there is an increasing number of MPAs being established globally (Lubchenco & Grorud-Colvert 2015; Boerder, 2018).

However, protecting highly migratory species presents a unique conservation challenge for spatial management through MPAs because population abundance is influenced by geographically separated events that occur during different periods of the year (Martin et al., 2007). As a result, designing effective conservation plans for migratory species is conceptually challenging, and to date, strategies have failed to adequately consider migratory connectivity — the idea that migratory animals are spatially connected between different periods of their annual cycle (Martin et al., 2007). While the benefits of MPAs for sessile species, habitats, and ecosystems have been widely documented (Da Silva et al. 2015, Friedlander et al. 2017, Tewfik et al. 2017), there is still considerable debate around whether they are an appropriate conservation strategy for highly migratory pelagics. Indeed, the argument that many of these species roam too far to benefit from stationary protected areas has been well established (Boerder et al., 2018; Game et al. 2009; Davies et al. 2012; Hooker and Gerber 2004). Thus, many researchers question the ability of MPAs to meaningfully contribute to the recovery of migratory species populations. However, recent research has proposed that well-designed 'networks' of marine protected areas may have the potential to contribute to the conservation and protection of highly migratory and transboundary species, including species at risk, through the protection of critical lifecycle stage habitats and by accounting for and protecting the connectivity between these core areas (Worboys et al., 2016).

While several evaluation frameworks have been developed to assess the effectiveness of MPAs, few, if any, have been developed for the purpose of evaluating the effectiveness of MPAs or MPA networks for the conservation of migratory marine species (Hinch and De Santo, 2011). The International Union for the Conservation of Nature World Commission on Protected Areas (IUCN-WCPA) published a report outlining a "best practice" framework for building resilient and functional MPA networks, the core of which is composed of the 5 biophysical and ecological guidelines deemed most relevant for designing and implementing MPA networks (IUCN-WCPA, 2008). However, since the IUCN guidelines are meant to serve as a general framework for MPA network design with broad application across habitats and species, their adequacy for designing effective MPA networks for migratory species conservation is uncertain. Moreover, there are very few, if any, established MPA 'networks' designed on the basis of best practice guidelines, and none that have been designed for large migratory pelagics. As a consequence, there are diverse perspectives among MPA managers, planners and scholars as to the potential effectiveness of MPA networks for the conservation of large, migratory pelagic species, and no existing MPA networks by which to gauge their effectiveness. Consequently, the question of whether or not MPA networks, if designed for these species, could be potentially effective, remains open and disputed in the literature and in practice.

1.2 OBJECTIVES & METHODOLOGICAL APPROACH

The overarching goal of my thesis is to help inform and reconcile the debate surrounding the utility of MPA networks for the conservation of migratory pelagics by synthesizing the current state of knowledge depicted within the scientific literature as well as conveyed through interviews with experts in the field. In particular, I ask:

1) are the five IUCN ecological and biophysical guidelines for MPA network design addressed within the current scientific literature; and, inversely, are the themes emphasized within the literature around the effectiveness of MPA networks for migratory species reflected within the IUCN guidelines;
2) what comprises the nature, basis and range of expert judgements on the potential effectiveness of MPA networks for migratory pelagics; and,
3) what are the most pressing challenges and opportunities associated with fostering a common understanding and collaborative approach to designing and establishing effective MPA networks for conserving migratory species.

To achieve these objectives, this study utilized two primary methods: a systematic literature review, and semi-structured interviews with experts. The systematic literature review searched for studies analyzing the effectiveness and benefits of MPAs and MPA networks for at-risk pelagic species, and Covidence online software was used to track and record the various database search results. Semi-structured interviews were conducted with experts possessing extensive knowledge of marine pelagics native to the North Atlantic and/or experience with MPA design and/or marine conservation planning. NVivo text analysis software was used for interview transcription as well as for thematic coding of both literature and interview data.

1.3 ORIENTING THE READER – THESIS STRUCTURE

My thesis is organized into four chapters; an introductory chapter, two stand-alone research papers, and a final concluding chapter. Given that chapters 2 and 3 are written in the format of independent papers to be submitted for publications, they include their own introductions, objectives, methods, results, and discussions. Because they were written to be stand-alone pieces, there is some redundancy in content, particularly within their respective introductions, methods and discussions. Chapter 2 introduces the systematic literature review which sought to survey the current literature to determine the state of knowledge and important themes/factors for determining the potential effectiveness of MPA networks for migratory pelagics, and thus addresses objective one. Chapter 3 outlines the expert interview study, designed to assess experts' professional judgements about the effectiveness of MPA networks for the conservation of these species, and thus addresses objective 2. The final chapter provides a synthesis discussion focused on the implications of the research findings from both papers and discusses future directions for research, and thereby addresses objective 3. Together, they achieve the goal of my thesis, helping to inform and reconcile the debate surrounding the utility of MPA networks for the conservation of migratory pelagics.

The work contributes to an important gap in knowledge. A recent study by Dudley et al. (2018) identified the top 100 priorities for protected area research globally, and among them were (i) protected areas for the conservation of threatened species, and (ii) networks of protected areas to protect migratory species throughout their life cycles. Addressing questions of MPA network effectiveness is especially prudent in light of current efforts to meet international commitments for MPA designation, particularly those under Aichi Target 11, as well as the current focus by the United Nations on protecting biodiversity in areas beyond national jurisdiction. Findings from the literature review and the expert interviews help to elucidate current factors influencing judgements around the potential effectiveness of MPA networks for conserving migratory pelagics. Such judgments both reveal and represent potential barriers and opportunities to the establishment of MPA networks, and potentially to the conservation of large, at-risk, migratory pelagic species. As such, the research performed in this thesis should be of interest to marine conservation scholars, advocates, and managers alike.

CHAPTER 2: ASSESSING THE ECOLOGICAL EFFECTIVENESS OF MPA NETWORKS FOR LARGE MIGRATORY AT-RISK PELAGICS IN A CONTEXT OF CLIMATE CHANGE: A REVIEW

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Abstract: Migratory pelagic species have received conservation attention due to their vulnerable and threatened status, as well as the important role they play in various ecosystem dynamics. Networks of Marine Protected Areas have been proposed as one tool to for their protection (Dudley et al. 2018), but significant debate exists surrounding their utility, and few evaluation frameworks of the effectiveness of MPAs have been designed for migratory species specifically. The IUCN-WCPA (2008) outlines five ecological guidelines for designing resilient and effective MPA networks, and this review systematically examines and synthesizes recent literature to: (1) assess the degree to which the five guidelines and their respective strategies are addressed for large migratory at-risk pelagic species (hereafter, migratory pelagics); (2) assess differences between the literature and IUCN guidelines in the way MPA networks are conceptualized and operationalized for these species; (3) to identify additional relevant themes for the conservation of migratory pelagics within MPA networks that are not addressed by the IUCN guidelines; and, (4) to identify remaining challenges for the effective use of MPA networks for this suite of species.. Findings indicate that the majority of IUCN guidelines are too broad to be of practical use for migratory pelagics, and that the current literature fails to adequately address the importance of space, shape, and the protection of migratory routes as considerations in MPA network design. Given the global distribution of these species, the effectiveness of MPA networks depends critically on international collaboration and management. To this end, greater clarity and consistency around the use of key concepts is warranted, particularly ‘protected area’, ‘critical habitat’, and MPA ‘system’ and ‘network’.

Keywords: migratory pelagics, marine protected area, network, design, IUCN guidelines, connectivity, linkages, conservation

2.1 INTRODUCTION

Populations of several charismatic migratory pelagic species, such as sharks, sea turtles, and marine mammals, are facing wide-scale population declines (Lascelles et al., 2014, Schipper et al., 2008). In a review of 120 marine mammal species, Schipper et al. (2008) concluded that 36% of large marine vertebrates are globally threatened. All species of sea turtles for which data are available are of conservation concern (IUCN, 2010; Lewison and Crowder, 2007), and nearly one third of shark species are vulnerable to extinction (Dulvy et al., 2014). Those declines exacerbate threats facing marine ecosystems due to the important roles of large consumers in regulating the structure and function of habitats (Ripple et al. 2014; Scott et al., 2012; Estes et al. 2011). Further, threats to migratory species and the ecosystems that support them are complicated by oceanic changes, such as those associated with climate change (Greene and Pershing, 2004; CMS, 2008; Mazaris et al., 2009; Witt et al., 2009).

Networks of Marine Protected Areas (MPAs) have been proposed as one tool to protect migratory species (Dudley et al. 2018) but few evaluation frameworks of the effectiveness of MPAs have been designed for migratory species specifically (Hinch and De Santo, 2011). Further, existing MPAs and MPA networks arguably have not been designed and implemented for long-term, population-level protections of wide-ranging and large-area requiring species, and are often deemed ineffective for protecting such species (e.g., Boerder et al., 2018; Game et al. 2009; Davies et al. 2012; Hooker and Gerber 2004; Hilborn et al. 2004; Gruss 2014).

The International Union for the Conservation of Nature World Commission on Protected Areas (IUCN-WCPA) published a guidance report outlining a "best practice" framework for building resilient and functional MPA networks. While the guide consists of eight chapters intended to be considered in parallel, a single chapter outlines five ecological guidelines for designing MPA networks: (1) including the full range of biodiversity present in the biogeographic region; (2) ensuring ecologically significant areas are incorporated; (3) maintaining long-term protection; (4) ensuring ecological linkages; and, (5) ensuring maximum contribution of individual MPAs to the network (IUCN-WCPA, 2008) (Table 1). Each ecological guideline is accompanied by a set of recommended design principles to apply when establishing MPA networks. Conceptualization, knowledge and guidance around connectivity have progressed significantly since the development of the IUCN-WCPA's (2008) guidelines (e.g., Worboys et al. 2016), especially in the marine realm (Calabrese and Fagan, 2004; Cowen and Sponaugle, 2009; Magris et al., 2018, 2016, 2014; Bryan-Brown et al., 2017). Thus, the 2008 guidelines may no longer reflect best practice or the current state of scientific knowledge on the design of resilient MPA networks. Despite such advances, however, Balbar and Metaxas (2019) found that only 11% of the 746 MPAs examined considered ecological connectivity as an ecological criterion within their management plans.

This review systematically examines and synthesizes recent literature (2000-2018) to: (1) assess the degree to which the five IUCN ecological guidelines and their respective strategies for establishing resilient MPA networks meet the conservation requirements of large migratory at-risk pelagic species (hereafter, migratory pelagics) as represented in the reviewed literature; (2) assess differences between the literature and IUCN guidelines in the way MPA networks are conceptualized and operationalized for these species; (3) identify gaps in the literature and suggest revisions to the guidelines as required to improve their applicability to migratory species; and, (4) identify remaining challenges for the effective use of MPA networks for this suite of species. This review also highlights challenges associated with the conservation of migratory pelagics, with a focus on marine spatial planning. Our review is timely in marine protected area research, particularly for designing MPA networks to protect threatened and migratory species and habitats, and in the context of a changing climate (Dudley et al., 2018).

Table 1: Ecological guidelines for designing resilient MPA networks (summarized from IUCN-WCPA, 2008)

Guideline	Explanation
1. Protect the full range of biodiversity present in the biogeographic region	"MPA networks should represent the range of marine and coastal biological diversity – from genes to ecosystems – and the associated oceanographic environment within the given area …. MPA networks should include replicates of each representative habitat within the biogeographic region .... Habitats that exhibit characteristics of resistance and resilience to climate change can be a vital component of MPA networks, since more resilient networks may be able to resist or adapt to long-term changes" (p. 40 – 43).
2. Ensure ecologically significant areas are incorporated	"Biologically and ecologically significant areas, such as unique habitats, spawning aggregations and nursery areas, play a crucial role in sustaining populations and maintaining ecosystem function and should be considered in MPA network design" (p. 45).
3. Ensure long-term protection	"Network design must provide long-term protection, including no-take zones, to effectively conserve diversity and provide ecosystem benefits; long-term arrangements for funding, management and enforcement are essential for effective management" (p. 48).

4. Ensure ecological linkages	“MPA network design should seek to maximize and enhance the linkages among individual MPAs and groups of MPAs within a given network” (p. 52).
5. Ensure maximum contribution of individual MPAs to the network	“The size, shape and spacing of the MPAs in the network greatly influence the connectivity in the network, the degree to which there are edge effects and the ease of enforcement of the MPAs” (p. 58).

2.2 CONSERVATION THROUGH MPAs & MPA NETWORKS

The habitat of oceanic pelagic species encompasses the water column from the surface of the ocean to a depth of 200 m (Moyle and Cech, 2004). Migratory marine species have wide geographic distributions, both within countries’ exclusive economic zones (EEZ) and in areas beyond national jurisdictions (ABNJ). Further, these species have agile bodies made for long distance migration (NOAA, 2018), and typically engage in significant annual migrations for feeding, reproduction, or other life-history stages and behaviours (Maguire et al., 2006; Martin et al., 2007; Block et al., 2011; CMS, 2013; Lascelles et al., 2014). These extensive migrations expose migratory species to multiple direct and indirect threats, which together have cumulative negative consequences for populations, especially those already in decline. Direct physical threats include entanglement by fisheries (Read et al., 2006), ship strikes (Van Waerebeek et al., 2007), acoustic threats caused by seismic drilling and other activities (Weilgart, 2007; Gomez et al., 2016), and environmental threats, most often pollution (Baulch and Perry, 2014) or shifts in oceanographic conditions (Hooker and Gerber, 2004; Simmonds and Isaac, 2007; Kaschner et al., 2011; Avila, Kaschner and Dormann, 2018). Additional negative impacts include loss of habitat, reduced ocean productivity, shifts in locations of prey, habitat shifts due to changes in ocean currents and sea surface temperature, and direct mortality (Greene and Pershing, 2004; Polovina et al., 2004; Fish et al., 2005; CMS, 2008; Witt et al., 2009; Mazaris et al., 2009; Lascelles et al., 2014). Some species may benefit positively from the availability of new feeding or breeding areas, however this response depends largely on taxon-specific and ecological traits (Burek et al., 2008; Foden et al., 2013; Lascelles et al 2014). Since the threats facing migratory species can be both site specific and more widely distributed across their entire range, the appropriate management strategy will be threat-specific, with some threats managed at the ocean-basin scale, such as through fleet-wide fisheries regulations, and others using spatially-based approaches in key habitat areas (Hooker and Gerber, 2004; Lambeck et al., 1997; Lascelles et al., 2014). Ecosystem-based management approaches comprised of diverse portfolios of conservation measures are required, such as spatial protection through MPAs in conjunction with other management strategies applied across broad geographic areas.

MPAs are increasingly used as a spatial management tool, as signatory nation states to the Convention on Biological Diversity (CBD) have committed to protect 10% of oceans as MPAs by 2020. The term ‘MPA’ is normally used as an umbrella term to describe all spatial management tactics that meet the IUCN definition of ‘protected area’, including marine reserve, sanctuary, and marine park (IUCN-WCPA, 2008). Effective protection through MPAs helps maintain ecosystem health and productivity and may also enhance or restore the productivity of coastal and marine fisheries through the improved recovery of exploited species (IUCN-WCPA, 2008). MPAs are managed to include a spectrum of protection, ranging from fully protected areas where all access is restricted, to multiple-use areas that integrate fisheries management objectives, so long as they reflect the various components of the protected area definition (i.e., defined; recognized; legal or other effective means; long-term; conservation of nature; etc.) (Day et al., 2012). In keeping with IUCN standards, this review (1) uses the term MPA to refer to all spatial management areas implemented to conserve biodiversity that meet the IUCN definition of a 'protected area' and (2) recognizes that MPAs may vary in purpose and design (IUCN-WCPA, 2008a).

Table 2: Glossary of Key Terms – PA, MPA, MPA 'network', MPA 'system', Connectivity Conservation Area

Protected Area (PA)	"A clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Day et al., 2012, p. 12).
Marine Protected Area (MPA)	A marine area that adheres to the IUCN definition of a protected area (Day et al., 2012).
MPA Network	"A group of PAs with connectivity between them"; and, accommodating 'connectivity' is one of the defining features of MPA 'networks'" (UNEP- WCMC, 2008, p. 20). "A collection of individual marine protected areas or reserves that operates cooperatively and synergistically, at various spatial scales, and with a range of protection levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could alone" (IUCN-WCPA, 2008, p. 12).
MPA System	Sets of systematically selected MPAs that are planned and managed to achieve particular objectives related to the whole set (e.g., representation objectives) (Agardy and Wolfe, 2002).
Connectivity Conservation Area	"A recognised, large and/or significant spatially defined geographical space of one or more tenures that is actively, effectively and equitably governed and managed to ensure that viable populations of species are able to survive, evolve, move and interconnect within and between systems of protected areas and other effective area based conservation areas" (Worboys et al., 2016, p. 17).

The dynamic spatial and temporal distributions associated with migratory species and pelagic environments makes their protection and management more challenging than that of sessile organisms (Ashe et al., 2009; Hinch and De Santo, 2010; Davies et al., 2012; Perez-Jorge et al., 2015; Geijer and Jones, 2015), particularly when attempting to use MPAs as an appropriate conservation strategy (Boerder et al., 2018; Game et al. 2009; Davies et al. 2012; Hooker and Gerber 2004). Studies focused on understanding the efficacy of MPAs have concluded that isolated MPAs, regardless of size, cannot effectively protect migratory pelagics, such as sea turtles, sharks, and marine mammals from threats across their entire range; these species will inevitably travel outside of individual protected area boundaries at some point during their migration (for example, Reeves, 2000; Augustowski & Palazzo, 2003; Hooker and Gerber, 2004; Notarbartolo Di Sciara et al., 2008; Hinch and De Santo, 2011; Hooker et al., 2011; CMS, 2012; Geijer and Jones, 2015). Alternatively, well-designed networks of MPAs have the potential to contribute to the conservation of migratory species, including endangered and threatened species, through the protection of critical habitats (DFO, 2016; White et al., 2017; O'Leary et al., 2018) and through the reduction of species' cumulative exposures to threats (Hinch and De Santo, 2011; Hooker et al., 2010; Hooker and Gerber, 2004), including along migratory pathways and linkages between MPAs (Hyrenbach, 2000; Augustowski and Palazzo, 2003; Mullen et al., 2013; Geijer and Jones, 2015; Worboys et al., 2016). Thus, we expect the results of this review to find that within a broader ecosystem-based management approach, well-designed MPA networks are likely to be the only viable area-based conservation strategy for highly migratory species.

The implementation of an MPA network is challenging because not all collections or systems of individual MPAs and management areas constitute a connected network. Confounding matters further, an important distinction between systems and networks of MPAs is not elucidated in the official IUCN definition of an MPA network (IUCN, 2008). According to Agardy and Wolfe (2002), MPA systems are sets of systematically selected MPAs that are planned and managed to achieve particular objectives related to the entire set. In contrast, a network refers to a group of MPAs that are specifically planned as connected systems, and accommodating connectivity is one of the defining features of MPA networks (UNEP- WCMC, 2008). MPA networks and systems lack globally accepted definitions and thus are often used interchangeably in marine conservation literature and policy-relevant documents (Aichi Target 11 in the Strategic Plan for Biodiversity [SCBD 2010] refers to ‘well connected systems of MPAs’). More recent IUCN guidance (Worboys et al., 2016) specifically addresses connectivity, establishes a clear definition for connectivity conservation areas (CCAs), and defines criteria for their international recognition. Nonetheless, confusion around interpretation of the terms persists in MPA literature and practice.

2.3 SYSTEMATIC LITERATURE REVIEW METHODOLOGY

Currently, very few, if any, MPA networks exist that have been established for the purpose of migratory species conservation (see, for example, Pendoley et al., 2014). Consequently, studies on the use of MPA networks for migratory pelagics are theoretical and draw their conclusions from analyses of species use of and movements around isolated MPAs or MPA systems. To reflect this reality, this review is not limited to sources with an explicit focus on MPA networks but adopts a broader approach that includes all spatial management strategies that could potentially form part of an MPA network. A search was conducted for studies (peer reviewed journal publications, reports, scholarly theses, and government research reports) that analyze the conservation benefits of marine protected areas for migratory at-risk pelagic species. These documents were: (1) revealed using key word search strings in online bibliographic databases, including Web of Science, Aquatic Science and Fisheries Abstracts, Biological Abstracts, and Oceanic Abstracts, and grey literature, including directed searches on Google Scholar (see Table 2); (2) recommended directly by marine conservation experts such as scientists, planners and managers; and, (3) noted in the reference sections of selected articles. Database search results were sorted by publication year and limited to those published between 2000 and 2018 to yield only recent publications; no document type constraints were applied. Grey literature directed searches of specialist conservation and government websites were utilized, including the Department of Fisheries and Oceans of Canada (DFO), World Wildlife Fund (WWF), International Union for the Conservation of Nature (IUCN), Convention on Migratory Species (CMS), and the World Commission on Protected Areas (WCPA), and the first 80 hits of each respective search were assessed to determine their relevance or fit.

Table 3: Literature Review Keyword Search Strings

Spatial Management		Species of Focus		Conservation Status
"marine protected area"		migratory		"at risk"
OR		**OR**		**OR**
MPA		transboundary		endangered

OR "marine reserve" **OR** "marine protected area network"	**AND**	**OR** pelagic	**AND**	**OR** threatened

The analysis is limited to papers that address the effectiveness of spatial protection for the conservation of endangered migratory marine sea turtles, sharks, and marine mammals that inhabit the pelagic realm at some point throughout their lifecycle. For the purposes of this review, an effective MPA network is defined as providing spatial areas of protection from threats for individuals, groups and key habitat components, across seasonal and life-history requisites; and that are sufficiently large and connected to maintain and/or restore viable populations of these species over the long term (i.e. centuries). This review excludes studies that focus on the conservation of terrestrial species, migratory seabirds and/or other fish species, given that these have received extensive study (see, for example, Anderson et al., 2003; Hillborn et al. 2004; Trebilco et al., 2008; Péron et al., 2013; Young et al., 2015). Studies are also excluded if they focus solely on species tracking to identify patterns in habitat use.

A total of 833 sources were obtained and imported into Covidence Software. After title and abstract screening, 694 of those sources were deemed tangential to the study focus. Full text screening of the remaining 139 articles identified 57 sources (53 published research articles, 3 government reports, and 1 PhD Dissertation) that met all inclusion criteria. These sources discuss the role of existing (n=40) and hypothetical (n=13) isolated

MPAs, existing MPA systems (n=7), and theoretical MPA networks (n=25) for the conservation of migratory species. Studies were characterized using the definitions established for this review, regardless of how the authors use them (i.e. all studies classified as discussing the role of MPA networks acknowledge the presence of connectivity between individual MPAs, while those classified as discussing MPA systems assess the role of multiple MPAs working as a whole but without specific reference to connectivity between them).

The 57 sources were imported into NVivo 12 software and thematically analyzed, qualitatively and quantitatively, for evidence of the IUCN's five general ecological guidelines and key strategies (IUCN-WCPA, 2008) (Table 4). Each guideline was imported into NVivo as an *a priori* 'parent case study node'; the strategies of each guideline were imported as *a priori* 'child nodes'; and, relevant 'bits' of data (i.e. key words, phrases, quotes) from source content were coded to each (Table 4). Using the same process, source content was coded *a posteriori* to additional 'case study nodes' and 'child nodes' that were not explicitly included in the IUCN summary table but emerged from the reviewed literature as relevant to the effectiveness of MPAs for the conservation of migratory pelagics. All *a priori* nodes were analyzed to assess the degree to which the IUCN guidelines were addressed in studies of MPA networks, systems and isolated MPAs for the conservation (i.e., protection and/or restoration) of large migratory at-risk pelagic species in a context of climate change. NVivo text search queries were also run on each child node to quantitatively analyze the representation of each strategy's inclusion in the literature.

Since the IUCN guidelines are meant to serve as a general framework for MPA network design with broad application across habitats and species, we only included the guidelines and strategies deemed relevant to the conservation of migratory species (Table 4). The "protection of unique and vulnerable features" and "protection of source populations" (IUCN-WCPA, 2008, p 62) strategies under guideline two are tangentially relevant to our study. While the former emphasizes endangered and/or threatened species, which include many migratory pelagics, it is not directly relevant to assessing the potential effectiveness of MPA networks for those species and their associated ecosystems, and the protection of source populations within ecosystems is repetitive of the protection of foraging, breeding and migratory components present in other guidelines. The *spillover* strategy under guideline three refers to processes whereby fisheries benefit through increased production of eggs and larvae from the protected area and the net movement of adults into adjacent fishing grounds (Buxton et al., 2014). However, migratory pelagic species, such as sharks, whales, and sea turtles, do not have a larval phase, and our assessment is not focused on benefits to fisheries. Lastly, the criteria "consider adult movement" and "consider adult movement patterns" (IUCN-WCPA, 2008, p 62) were merged to avoid repetition in analysis.

Table 4: IUCN guidelines and strategies adapted from 'Table 9: summary of ecological guiding principles' in IUCN-WCPA (2008; see Appendix X). Guideline strategies relevant to the design and management of MPA networks for migratory pelagics are indicated in bold font and represent 'child' nodes used in the content analysis.

IUCN Ecological Guideline (*A priori* coding: 'parent node")	Strategies (*A priori* coding: 'child node')
1. Include the full range of biodiversity present in the biogeographic region	**Representation:** Represent a minimum of each habitat type and physical environment type in the overall MPA network **Replication:** Have sufficient replication to safeguard against catastrophic events or disturbances **Representation of resilient and resistant characteristics:** Chose sites that are more likely to be resistant or resilient to global environmental change

2.	Ensure significant areas are incorporated	Protection of unique or vulnerable habitats: Design MPAs to include biophysically special and unique places **Protection of foraging or breeding grounds:** Design MPAs to include important areas for breeding, feeding or socializing areas (rookeries, haul-outs, nesting, etc.) Protection of source populations: Design the MPA to include important sources of reproduction (nurseries, spawning areas, egg sources, etc.). MPAs located at source populations, when identifiable, can help retain recruits and larvae to sustain local populations, as well as serve to export surplus larvae
3.	Maintain long-term protection	Consider spillover: Spillover of adult and juvenile fishes and invertebrates can contribute to populations in fished waters outside MPAs but may not be evident for years after protection **Adaptive management**: Include adaptive strategies in the MPA design which allow for adjustments as science evolves and community dynamics change. Design the MPA boundaries to be flexible in space and time so that they can be expanded or contracted, have seasonal or other time limits, be moved to different levels of protection, and so to be made more responsive to changing conditions (ecologically, social, economically)
4.	Ensure ecological linkages	**Connectivity**: Recognize the patterns of connectivity within and among ecosystems (e.g. ecological linkages among coral reefs, seagrasses and mangroves) **Consider adult movement and larval dispersal:** Larval dispersal and adult movement vary greatly with species; design size and spacing of MPA network to maximize benefits **Consider adult movement patterns:** Adult movement patterns and distances vary greatly with species, which influence the design of the MPA and response of species after the MPA is created
5.	Ensure maximum contribution of individual MPAs to the network	**Consider size:** Design individual MPAs large enough to (1) accommodate the large-scale movement of adults and (2) include enough habitat for viable species and ecosystem protection **Consider spacing:** Design network of MPAs to (1) accommodate the long-distance dispersal of larvae and (2) capture the biogeographic range of variation in habitats and species **Consider shape:** Design the shape of individual MPAs to: (1) take into account edge habitat (for biodiversity conservation it is important to minimize edge habitat and maximize interior protected area; in contrast, for fisheries management continuous habitat inside and outside of the reserve will enhance spillover effects); (2) maintain the latitudinal and longitudinal gradient in habitats and communities; and (3) facilitate enforcement

2.4 RESULTS

The scientific literature on MPAs for migratory pelagics provided adequate coverage of the majority of the IUCN ecological guidelines, although the coverage of the guidelines varied among the reviewed studies (Table 5). Of all the IUCN guidelines, guideline four (*Ensure ecological linkages*) received the most attention in the scientific literature, with all but six papers (n=51) addressing one or both of the strategies, followed closely by guideline two (*Ensure ecologically significant areas are incorporated*) (n=50) and guideline one (*Include the full range of biodiversity present in the biogeographic region*) (n=45). A single study addressed all guidelines and strategies (Hooker et al., 2011). Differences emerged among studies in the operationalization of the guidelines and strategies (Table 5).

Table 5: Matrix depicting content related to IUCN guideline (theme node) and guideline strategies (child node) in reviewed papers. # - Source number (see App X for key to full citation); G.1 - Include the full range of biodiversity present in the biogeographic region; G.2 - Ensure ecologically significant areas are incorporated; G.3 - Maintain long-term protection; G.4 - Ensure ecological linkages; G.5 - Ensure maximum contribution of individual MPAs to the network

Article #	G.1			G.2	G.3		G.4		G.5		
	Representation	Replication	Resilience/ Resistance	Foraging& Breeding Grounds	Adaptive Management	Dynamic MPAs	Connectivity	Adult Movement Patterns	Size	Spacing	Shape
1			X	X	X			X			
2	X		X	X	X		X	X	X		
3			X	X	X	X	X	X	X		X
4	X			X			X	X	X		
5	X		X	X			X	X	X	X	X
6				X				X	X		X
7	X		X	X	X	X	X	X	X		
8			X	X				X			
9			X	X	X		X	X			

10	X			X	X		X	X	X		
11	X		X	X	X	X		X	X		X
12			X	X	X		X	X	X		
13			X	X					X		
14	X	X	X	X	X		X	X	X	X	
15	X		X		X	X		X	X	X	
16	X	X	X	X	X	X	X	X	X	X	X
17	X			X				X	X		X
18	X		X				X		X		
19				X					X		
20	X		X	X	X			X			
21			X	X	X	X	X	X			
22	X		X	X	X			X	X		
23	X		X	X			X	X	X		
24	X		X	X	X	X	X	X	X		
25				X			X	X	X		
26	X		X	X			X	X			
27	X			X	X		X	X	X		X
28	X			X	X		X	X	X		
29				X	X	X	X	X	X		X
30	X		X	X			X	X	X		
31					X		X	X	X		
32				X			X	X			
33	X	X		X	X		X	X	X		X
34			X	X	X	X	X	X	X		X
35	X			X			X	X	X		X
36			X	X	X		X	X	X		X
37	X		X	X	X	X	X	X	X		
38	X		X		X		X	X	X		
39		X	X		X		X	X	X	X	
40	X			X			X	X	X		
41	X		X	X	X	X	X	X	X		
42			X	X	X			X	X		X
43	X			X				X	X		
44			X	X			X	X	X	X	
45				X			X	X			
46				X			X	X			
47				X							
48			X								
49				X	X			X			
50	X			X	X		X	X	X		
51				X					X		
52				X				X			
53			X	X	X	X	X	X	X	X	
54			X		X				X		X
55				X			X	X			
56				X			X	X			
57	X	X	X	X	X		X	X	X	X	
Σ	28	5	33	50	32	12	39	50	42	8	18
	43 (75%)			50 (88%)	32 (56%)		51 (89%)		42 (74%)		

2.4.1 Guideline One – Protect the full range of biodiversity present in the biogeographic region

The three strategies of guideline one (representation, replication, and resilience and resistance) are intricately connected; ensuring that networks represent and replicate all habitat types may enhance resilience by accommodating changes in species' distributions and ocean conditions that will result from climate change impacts (IUCN-WCPA, 2008).

Representation – Because most studies assessed effective protection of critical life-stage habitats for migratory pelagics within isolated/single MPAs, it was largely outside of their scope to assess effective representation at the scale of entire networks (Hooker and Gerber, 2004; Notarbartolo di Sciara et al., 2008; Davies et al., 2012; Scott et al., 2012; Perez-Jorge et al., 2015; O'leary et al., 2018). Nonetheless, many studies explicitly identified representation as an important ecological principal (Reeves, 2000; Augustowski and Palazzo, 2003; Norse et al., 2005; Hooker et al., 2011; Lascelles et al., 2014; Harris et al., 2015; Davies et al., 2017). For example, Davies et al. (2017) recommended strategically selecting new large MPAs to increase representation of marine mammals and shark species in MPA networks. Guideline one acknowledged the elements of representation referenced in the literature, namely the representation of habitat types to capture the life-stage shifts, across species' entire migratory routes (e.g., breeding, foraging, nesting habitats etc.) (Hyrenbach et al., 2000; Augustowski and Palazzo, 2003; Chapman et al., 2005; Notarbartolo di Sciara et al., 2008; Hoyt, 2009; Reynolds et al., 2017).

Replication – Of the three strategies of Guideline one, 'replication' was the most underrepresented in the literature**,** where it was only identified as important when providing stepping stones to the dispersal of migratory species (Norse et al., 2005; King and Beazley, 2005; Hinch and De Santo, 2011; Hooker et al., 2011) and for buffering against mismanagement (Hooker et al., 2011) or changes in environmental conditions (i.e. climate change) (Hinch and De Santo, 2011; Hooker et al., 2011; Worboys et al., 2016; Roberts et al., 2017). The stepping-stone approach involves the protection of stop-over sites such as feeding areas along the migratory route, and replication ensures that more than one example of each of these is included in a network design (King and Beazley 2005; Hooker et al. 2011); and, this redundancy can help mitigate impacts from climate change (Worboys et al. 2016; IUCN-WCPA, 2008).

Resilience and resistance characteristics – According to Guideline one, MPA networks should include sites that are likely to be resistant or resilient to environmental change (IUCN-WCPA, 2008). Several studies showed that resilient MPA networks will allow for migration and species range shifts in reaction to changes in environmental conditions (CMS, 2008; Game et al., 2009; Hinch and De Santo, 2011; CMS, 2012; Toonen et al., 2013; Worboys et al., 2016; Roberts et al., 2017; O'leary et al., 2018). The guideline indicated that representation of all habitat types in an MPA network will help accommodate changes in species distribution and thus promote resilience (IUCN-WCPA, 2008).

The resilience of MPA networks to climate change can be influenced by the size of individual MPAs within the network (Toonen et al., 2013; White et al., 2017; O'leary et al., 2018). While Guideline one did not explicitly acknowledge the role of this characteristic, the impacts of size were discussed thoroughly under Guideline five. A few studies argued that, because of their role as apex predators, MPA networks designed to protect critical habitats of migratory species may also enhance ecosystem stability, thereby promoting resilience and resistance (Hazen et al., 2013; Roberts et al., 2017).

Many studies also argued that the establishment of MPA networks that include a high proportion of no-take marine reserves, free of extractive uses, may enhance the conservation of large, migratory pelagics by limiting key threats to individuals and their habitat components within the protected area boundaries (Game et al., 2009; Gruss et al., 2011; Hinch and De Santo, 2011; Edgar et al., 2014; Roberts et al., 2017). While not specifically tailored to migratory pelagics, Guideline one supported these arguments (IUCN-WCPA, 2008).

2.4.2 Guideline Two: Ensure ecologically significant areas are incorporated

Guideline two was discussed in 50 studies (88%) with respect to the importance of protecting foraging and breeding habitat areas for migratory species. Most studies included in this review identified the protection of critical habitat as a necessary component of effective MPA networks for the conservation of migratory species, because protection can be achieved by reducing interactions with threats and safeguarding their prey base and habitats (Gerber et al., 2005; Norse et al., 2005; Ashe et al., 2009; Ceccarelli et al., 2014).

Protection of foraging and breeding grounds - According to the guideline summary, MPA networks should include important areas for breeding, feeding, or socializing (IUCN-WCPA, 2008). While the importance of foraging and breeding habitats was also documented in the literature, only a few studies considered the importance of protecting areas for socialization (Augustowski and Palazzo, 2003; King and Beazley, 2005; Hoyt, 2009; Ashe et al., 2009; Hinch and De Santo, 2011; Silva et al., 2012) (Table 4). Less than half of the studies addressed the importance of migration and nursery areas, and only two studies (Hinch and De Santo, 2011; King and Beazley, 2005) addressed all types of important areas.

Table 6: Matrix depicting the presence of content related to strategies of IUCN Guideline 2 – Ensure ecologically significant areas are incorporated – in reviewed studies.

#	Components of Guideline 2				
	Foraging Grounds	Breeding Grounds	Migration Routes	Nursery Grounds	Socialization Grounds
1		X			
2	X	X	X	X	
3	X	X	X	X	
4	X	X	X		X
5	X	X			
6	X	X	X		
7	X	X	X	X	
8	X	X			
9	X	X	X		
10	X	X	X		
11	X	X			
12	X	X		X	X
13	X	X			X
14	X	X	X	X	X
15					
16	X	X	X		
17	X	X			X
18					
19				X	
20	X				
21	X	X	X		
22	X	X			
23	X	X		X	
24	X	X	X		
25	X	X	X		
26	X	X	X	X	
27	X	X			
28	X		X		
29	X	X	X		
30	X	X			
31					
32	X	X	X	X	
33	X	X	X	X	X
34	X	X	X		
35	X	X	X	X	
36		X	X	X	
37	X	X		X	
38					
39					
40	X	X			
41			X	X	
42		X			
43	X	X			
44	X	X		X	
45	X			X	
46	X	X		X	
47		X		X	

48					
49	**X**		**X**		
50	**X**				
51				**X**	
52	**X**	**X**		**X**	
53	**X**	**X**		**X**	
54					
55	**X**		**X**	**X**	
56	**X**	**X**		**X**	
57	**X**	**X**	**X**	**X**	
Total	**43**	**41**	**24**	**24**	**6**

Table notes: Guideline 2 - "Biologically and ecologically significant areas, such as unique habitats, spawning aggregations and nursery areas, play a crucial role in sustaining populations and maintaining ecosystem function and should be considered in MPA network design" (IUCN-WCPA, 2008, p. 45).

According to most studies, migratory species are not equally vulnerable across their entire range but exhibit increased vulnerability in areas where they aggregate, such as demographically critical habitat areas, with the highest levels occurring in habitats used for breeding and foraging (Norse et al., 2005; CMS, 2008; Game et al., 2009; Ashe et al., 2009; Hooker et al., 2011; Silva et al., 2012; Lascelles et al., 2014; Perez-Jorge et al., 2015; Notarbartolo Di Sciara et al., 2016; Lindsay et al., 2016; Graham et al., 2016). These studies thus recommended the establishment of MPAs targeted at these vulnerable critical habitat areas, and concluded that when only a portion of a species' full range can be included in an individual MPA, as is often the case with large migratory pelagics, there is merit in protecting these particular habitats as part of a system or network of MPAs (Reeves 2000; Hooker and Gerber 2004; Norse et al. 2005; UNEP, 2007; Game et al. 2009; Hooker et al. 2011; Perez-Jorge 2015). However, to date, identification of critical habitat for MPA designation has focused on breeding and foraging areas at the expense of adequate protection for important migratory pathways (Hooker and Gerber, 2004; Hooker et al., 2011).

The protection of migratory habitat was discussed in only 42% of studies, significantly less than critical foraging and breeding habitats. Although the summary table highlighted only breeding, foraging, and socializing areas, guideline two did list migratory habitat as among the critical habitat areas to consider for protection within an MPA network (IUCN-WCPA, 2008). Further, the importance of species migration was addressed within Guideline four in reference to the strategies of connectivity and adult movement patterns.

2.4.3 Guideline Three: Ensure long term protection

Long-term protection - Long-term protection is an essential component in the IUCN definition of a protected area, which requires that they "should be managed in perpetuity and not as short term or a temporary management strategy" (Day et al., 2012, p. 13). Several studies supported the importance of long-term protection for biodiversity conservation, arguing that duration of protection is one of the most important determinants of MPA effectiveness (Russ and Alcala, 2004; Claudet et al., 2008; Hinch and De Santo, 2010; Davies et al., 2012; Edgar et al., 2014; Worboys et al., 2016; Friedlander et al., 2017). Guideline two acknowledged that the time to accrue social, economic, or environmental benefits from an MPA network will vary depending on the life history of the focal species. While some biological changes happen rapidly, the full effects of an MPA network for migratory species may take decades to become apparent given that many are characterized by slow growth, late age at maturity, and slow reproductive output (Graham at el., 2016). Thus, while adaptive, periodic, seasonal, or dynamic closures will likely be essential components of any effective MPA network for migratory species, according to guideline three, long-term and permanent closures will provide the greatest protection to species and ecosystems within the network boundaries.

Adaptive management – According to IUCN, incorporating adaptive management in the design of MPA networks is essential for ensuring long-term protection, especially for highly migratory species (p. 54), by (1) allowing for adjustments to be made as new knowledge evolves, and (2) permitting flexible boundaries that can be moved or adjusted in response to changing ecological, social, or economic conditions (IUCN-WCPA, 2008). Similarly, most studies defined adaptive management as a means for adjusting the boundaries of MPAs in the future when/if they become ineffective for the species of focus. Given the dynamic nature of the pelagic environment, coupled with climate change, many key habitats for pelagic species are likely to shift, and adaptive management can adapt to these shifts (Notarbartolo Di Sciara et al., 2008; Hoyt, 2009; Hobday, 2011; Hooker et al., 2011; Hinch and De Santo, 2011; Hazen et al., 2013; Perez-Jorge et al., 2015; Roberts et al., 2017). For example, the Inner Moray Firth was designated as a Special Area of Conservation (SAC) for bottlenose dolphin in 2005 based on the importance of the area for both breeding and feeding. Following its designation, the dolphin population expanded its range into areas considerably outside of the SAC, and as a result, the area provides less protection than originally planned (ICES, 2011; Silva et al., 2012). Nearly half the articles that discussed adaptive management argued for the establishment of 'dynamic' MPAs as a necessary adaptive strategy for migratory species (see for example, Davies et al., 2012; Game et al., 2009; Gruss et al., 2011). Similarly, the guidelines advocated for the inclusion of dynamic MPAs within MPA networks as an adaptive management strategy with particular application for the long-term protection of highly migratory species (IUCN-WCPA, 2008). Indeed, the IUCN-WCPA (2008) argued that the design of MPA networks for the conservation of migratory pelagics should take into consideration the protection of spaces related to key life history patterns and should be designed with a mixture of permanent and temporal closures that fluctuate.

However, dynamic MPAs introduce the potential for critical habitat areas to be damaged or degraded between periods of temporary protection (Lemieux et al., 2019). If such degradation is severe enough, these areas may become unsuitable to function as critical habitat areas for migratory species (Day et al., 2012). Arguments supporting dynamic MPAs, both in the literature and the guideline, focus on providing long-term protection of a particular ‘function’ (i.e. breeding or foraging) rather than protection of a particular “place” and its associated broader ecosystems. The ability to integrate dynamic approaches into the design of effective MPA networks in a way that will not compromise long-term protection remains a challenge and is an area of active research (Hyrenbach et al., 2000; Norse et al., 2005; UNEP, 2007; Game et al., 2009; Hobday, 2011; Notarbartolo Di Sciara et al., 2016).

2.4.4 Guideline Four: Ensure ecological linkages

Connectivity – Habitat fragmentation, which occurs when the pathways between critical habitat areas are not adequately protected, was one of the primary threats to migratory species identified in the literature (CMS, 2012; Mullen et al., 2013; Geijer and Jones, 2015). Consequently, scaling up from isolated protected areas to networks of connected MPAs was deemed critical for the protection of migratory species. Networks can maintain the natural range of migratory species through ecological and functional linkages between individual MPAs in the network (Reeves, 2000; King and Beazley, 2005; Mullen et al, 2013; Geijer and Jones, 2015; Boerder, 2018). ‘Connectivity’ is an important design element of MPA networks (UNEP- WCMC, 2008), a primary strategy of the IUCN guideline, and was referenced in over two-thirds of studies in this review (e.g., Worboys et al., 2016; Pendoley et al., 2014; Hinch and De Santo, 2011). One third of studies did not include any reference to connectivity (e.g., Gerber et al., 2005; Witt et al., 2008; Ashe et al., 2009; Harris et al., 2015), and instead focused on the role of isolated MPAs for migratory pelagic species, such as key bottleneck sites, near neritic breeding and nesting grounds or foraging hotspots.

For a network to ensure connectivity at the scale required for migratory species, it is essential that all critical habitat areas be protected (King and Beazley, 2005; UNEP, 2007; Hinch and De Santo, 2011; Mullen et al., 2013; Notarbartolo Di Sciara et al., 2016), including migratory corridors connecting foraging and breeding habitats (Pendoley et al., 2014; Geijer and Jones, 2015; Notarbartolo Di Sciara et al., 2016; O'leary et al., 2018). The protection of migratory habitat was discussed in less than half (42%) of the studies, and focused largely on the challenges of identifying and implementing oceanic corridors rather than on specific proposals for suitable migratory corridors (Hyrenbach et al., 2000; Hooker and Gerber, 2004; UNEP 2007; Hooker et al., 2011; Mullen et al., 2013; Geijer and Jones, 2015; but see Pendoley et al. 2014). This focus may be a result of the analyses used to identify migratory habitat and the difficulty in defining pelagic habitats (Hooker et al., 2011; Hyrenbach et al., 2000; Pendoley et al., 2014). While improvements in tracking technology may help close this gap, and some studies are acknowledging the need to identify migratory routes for pelagic species (Hooker and Gerber, 2004; Hooker et al., 2011; Mullen et al., 2013; Lascelles et al., 2014), in-the-sea protection of these areas remains largely theoretical (Pendoley et al., 2014).

Such a gap in protection can have severe consequences for the effective conservation of migratory pelagics within MPA networks; migratory species are vulnerable to threats during migration between their critical habitats, and thus ignoring these areas leaves individuals vulnerable in a significant proportion of their range (Hinch and De Santo, 2011; Mullen et al., 2013; Lascelles et al., 2014; Pendoley et al., 2014; Reynolds et al., 2017). Thus, the exclusion of movement corridors represents a major roadblock to MPA network design and pelagic conservation, and the perpetuation of this approach will further increase the threat of habitat fragmentation for migratory species. The IUCN Connectivity Conservation Area Guidelines (Worboys et al., 2016) offer a promising step towards closing this conservation gap, calling for formal recognition of "Connectivity Conservation Areas" (CCAs) for marine species as an essential accessory to marine protected areas. One type of CCA, a Marine Large-Scale Species Movement CCA, seeks to conserve migratory routes among individual MPAs (Worboys et al., 2016). At present, while the protection of migratory routes is referenced as a key ecologically significant area to include in an MPA network under Guideline two, it should be allocated the same level of importance as foraging and breeding habitats and thereby featured in the ecological guideline summary, and not solely in the supporting text.

Adult Movement Patterns – According to the ecological guideline summary, sizing and spacing of effective MPA networks must consider adult movement patterns (IUCN-WCPA, 2008), particularly when designed to conserve species with high rates and spatial extents of movement. Importantly, guideline four was the only one which contained a section on the protection of migratory species in the main text. It stated that large migratory species have the largest neighborhood sizes, defined as greater than 1000 kilometers, and acknowledged that there has been little consideration in designing MPA networks for this suite of area-demanding species. The guideline suggested that networks designed to protect highly migratory species would need to protect all habitats that provide key life history stages across the species entire range, including breeding, foraging, and nursery areas, as well as migratory routes (IUCN-WCPA, 2008). While all studies recognized the importance of adult movement patterns for MPA network design, several studies also acknowledged the importance of considering the movement of highly migratory juveniles (Hyrenbach et al., 2000; Maxwell et al., 2011; Gruss et al., 2011; Ceccarelli et al., 2014; Vandeperre et al., 2014; Hays et al., 2014; Chapman et al., 2015; Reynolds et al., 2017). Juvenile movement and life history stages are mentioned under guideline four in relation to establishing connectivity and determining the size and spacing considerations of individual MPAs within a network. Nonetheless, the direct reference to the adult life stage in the wording of the strategy (i.e. "consider adult movement patterns") suggests the conferral of greater importance for this life stage as compared to that of juveniles. However, guideline four did acknowledge the importance of protecting critical habitats across the full life cycle of a species (i.e. adult and juvenile critical habitats) within an MPA network.

Some studies suggested that spatial protection for migratory pelagic species may not be effective because of their high rates of adult movement, indicating that many of these species roam too far to benefit from stationary protected areas (Boerder et al., 2018; Game et al. 2009; Davies et al. 2012; Hooker and Gerber 2004). However, most studies suggested that MPA networks that protect and connect critical habitats can alleviate this shortcoming (Augustowski and Palazzo 2003; UNEP 2007; Hoyt 2009; Hinch and De Santo, 2011; Lascelles et al 2015; Geijer and Jones, 2015; Notarbartolo Di Sciara et al

2016). MPA network initiatives for migratory species have not been implemented to date, likely because of lack of adequate data on species migrations, abundance, and distribution throughout the lifecycle (Game et al., 2009; ICES, 2011; Hooker et al., 2011; Maxwell et al., 2011; Gruss et al., 2011; Davies et al., 2012; Mullen et al., 2013; but see Game et al., 2009; Jorgensen et al., 2009; Hooker et al., 2011; Block et al., 2011; Scott et al., 2012; Lascelles et al., 2014; Chapman et al., 2015; Notarbartolo Di Sciara et al., 2016). Other noted reasons for the lack of implementation included the absence of political will (Hays et al., 2014; Geijer and Jones, 2015) and a bias towards protecting large, remote areas as a means of reaching political targets, without adequate consideration of areas of conservation importance for migratory species (Chapman et al., 2005; Lascelles et al., 2014; Davies et al., 2017).

Site fidelity, a particular form of philopatric behavior that describes the repeated return of individuals to the same locations following periods of movement (Chapman et al., 2015), can predispose certain highly migratory species to benefit more from spatial protection within MPAs (Hooker and Gerber, 2004; Palumbi, 2004; Chapman et al., 2005; Jorgensen et al., 2009; Kaplan et al., 2010; Block et al., 2011; Davies et al., 2012; Scott et al., 2012; Ceccarelli et al., 2014; Vandeperre et al., 2014; Pendoley et al., 2014; Chapman et al., 2015; Boerder, 2018). While not all migratory pelagics exhibit consistent evidence of site fidelity, those that do restrict their movements to much smaller areas at particular times than may be expected given their high capacity for movement. This allows for concentrated management at more manageable spatial scales (Jorgensen et al., 2009). Thus, studies conclude that the effectiveness of MPA networks for conserving mobile species will be species-specific (Palumbi, 2004; Kaplan et al., 2010; Ceccarelli et al., 2014;

Chapman et al., 2015; Boerder, 2018). Despite the importance of site fidelity, guideline four does not directly reference this behaviour. However, site fidelity may arguably be implied or assumed given the focus in guideline two and three on ensuring that MPA networks provide protection to key life history areas (IUCN-WCPA, 2008).

Current and future movement patterns of many migratory marine species and their ecosystems are threatened by the impacts of global climate change, which may include loss of habitat (Hazen et al., 2013; Worboys et al., 2016), shifts in range and migration routes as a result of changes in sea surface temperature and ocean currents (Gruss et al., 2011; Toonen et al., 2013; Hazen et al., 2013; Worboys et al., 2016; Davies et al., 2017; Roberts et al., 2017; Boerder, 2018; O'leary et al., 2018), and shifts in the location and abundance of prey (Hazen et al., 2013; Lascelles et al., 2014; Roberts et al., 2017). However, the likely response of most migratory pelagic species to climate change impacts cannot be predicted accurately enough to determine the effectiveness of spatial management responses (CMS, 2008; Hobday, 2011). These high levels of uncertainty can distort the conclusions that are ultimately drawn about the effectiveness of MPAs for highly migratory species (Gruss et al., 2011). Climate change impacts on movement patterns were not considered within the summary table or main text of guideline four (IUCN-WCPA, 2008), although climate change was discussed thoroughly in guideline one and in other chapters of the guidance document.

2.4.5 Guideline Five: Ensure maximum contribution of individual MPAs to the network

The importance of size, spacing, and shape of the individual MPAs within an MPA network lies in their effect on promoting connectivity, limiting edge effects, and enhancing enforceability (IUCN-WCPA, 2008). While the guideline argued that design considerations vary depending on the conservation objectives of the network, it made no explicit consideration of the size, shape, or spacing considerations as they apply specifically to migratory pelagics.

Size – More than twice as many studies consider the importance of MPA size than shape or spacing (Table 3). Guideline five stated that individual MPAs must be large enough to accommodate large-scale adult movement and include enough habitat for viable species protection (IUCN-WCPA, 2018). It indicated that the optimal 'size' of each individual protected area within a network will depend on the movement characteristics of the focal species, that MPAs will be more effective if they are larger than the distance that adult focal species move, and thus, that MPA size constraints should be set by the more mobile species in a given area (also echoed in Guideline four) (IUCN-WCPA, 2008). Several studies supported the use of this approach in MPA network design, arguing that, in addition to warranting conservation attention in their own right as functionally important and/or vulnerable species, due to their "umbrella" status MPAs established on the basis of migratory species movement patterns will often incidentally encompass the movement and habitats of many other species (Reeves, 2000; King and Beazley, 2005; UNEP 2007; Mullen et al., 2013; Lascelles et al., 2014; Perez-Jorge et al., 2015; Geijer and Jones, 2015; Pendoley et al., 2016; Notarbartolo Di Sciara et al., 2016).

Most studies dismissed small, isolated MPAs as a viable conservation strategy for migratory species, and argued instead for two possible options for MPA design: large ecosystem-based MPAs that encompass the entire migratory range (Hinch and De Santo, 2011; Gruss et al., 2011; Scott et al., 2012; Ceccarelli et al., 2014; Davies et al., 2017); or, an ecosystem-based network of smaller MPAs encompassing habitats essential to lifecycle stages extending over the entire migratory area (Hinch and De Santo, 2011; Davies et al., 2012; Hooker et al., 2011). Guideline five supported both strategies (IUCN – WCPA, 2008).

Several benefits for the conservation of migratory species have been associated with large MPAs. First, they encompass a greater proportion of the total range and important habitats, such as nesting and foraging grounds, than smaller ones (Game et al., 2009). Second, they can ensure connectivity by facilitating the movement of various whales, sharks, and turtles between coastal and pelagic habitats (O'leary et al., 2018). Third, they provide space for climate induced range shifts, reduce the cumulative stressors on species by removing or limiting direct anthropogenic stressors, and promote larger, more resilient populations (Roberts et al., 2017; O'leary et al., 2018). Finally, large MPAs contribute to international conservation goals, including the CBD's Aichi Target 11, if established based on scientific evidence (Toonen et al., 2013; Davies et al., 2017; O'leary et al., 2018). However, many studies also criticized the designation of large MPAs, and argued that economic, social, and political considerations often result in large MPAs being situated in remote waters where threats are minimal and conservation potential is limited in order to reach such quantitative targets (Gerber et al., 2005; Chapman et al., 2005; O'leary et al., 2018; Davies et al., 2017).

Several studies suggested that targeted MPAs that encompass the smaller critical habitat areas may provide a feasible alternative to large MPAs (Kaplan et al., 2010; Maxwell et al., 2011; Gruss et al., 2011; Davies et al., 2012; Silva et al., 2012; Hays et al., 2014; Chapman et al., 2015; Harris et al., 2015; Boerder, 2018). However, identifying areas that are large enough to be biologically relevant (Silva et al., 2012) while being small enough to be politically, economically, and socially acceptable (Gruss et al., 2011) is also challenging. Others argued that dynamic MPAs would allow smaller but changing areas to be protected, rather than the larger fixed area that would otherwise be required for the same scope of protection (Norse et al., 2005; Game et al., 2009; Hooker et al., 2011; Gruss et al., 2011; Hobday, 2011; Davies et al., 2012; Lascelles et al., 2014; Boerder, 2018).

Overall, guideline five indicated that an optimal network will likely be composed primarily of intermediately sized MPAs, and include different MPA sizes (IUCN - WCPA, 2008); similarly, most studies concluded that effective conservation of highly migratory species will require connected networks of both large and small MPAs (Hinch and De Santo, 2011; Hays et al., 2014; Chapman et al., 2015; Roberts et al., 2017). However, all MPAs, regardless of size, require effective implementation and management, and effective conservation will depend on the zoning of large, long-term, no-take areas, as discussed in relation to guideline three (Edgar et al., 2014; O'leary et al., 2018). Thus, a decision-making process that prioritizes size considerations in isolation of other management factors will not optimize protection.

Spacing – Guideline five argued that the appropriate 'spacing' between MPAs that provide suitable habitat for a focal species is particularly important for ensuring connectivity in the network, and thus should be guided by the movement patterns of focal species. However, discussions of the importance of spacing considerations for ensuring connectivity within MPA networks designed for migratory species are largely absent from the literature. The guideline did not specifically mention the spacing considerations for migratory pelagic species, but instead focused more generally on the movements of any "adults, juveniles, larvae, eggs or spores of marine species…" (IUCN-WCPA, 2008).

Similarly, only a few studies (n=8) included any mention of the optimal spacing between individual MPAs in a network for migratory pelagics (Hooker and Gerber, 2004; Palumbi, 2004; Hinch and De Santo, 2011; Hooker et al., 2011; Hobday, 2011; Worboys et al., 2016; Roberts et al., 2017; Boerder, 2018), despite the fact that spacing is recognized as a key factor for achieving and maintaining connectivity. The ideal spatial configuration of MPA networks for migratory species remains an aspect of design in need of further research and analysis (Hooker and Gerber, 2004; Roberts et al.,2017). Neither the guideline nor the literature accounted for the impact of climate change on spacing considerations (but see Hobday, 2011).

Shape – Guideline five indicated that the shape of individual MPAs is important for minimizing edge habitat, maximizing interior protected area, maintaining the latitudinal and longitudinal gradient in habitats, and facilitating enforcement (IUCN-WCPA, 2008). Few studies (n=18) considered the importance of MPA shape in the design of networks for migratory species. However, those that did offered arguments that were largely consistent with those put forth in guideline five (Silva et al., 2012; Toonen et al., 2013; Hinch and De Santo 2011). For example, in their study of bottlenose dolphin use of a candidate MPA in the Azores, Silva et al. (2012) contended that MPAs with clear boundaries, and ideally with straight edges delineated by lines of latitude and longitude, can be more easily identified by both resource users and managers, thus promoting higher compliance and easier enforcement.

Additionally, guideline five stated that the shape of an MPA must aim to capture the onshore-offshore or habitat-habitat shifts of species over their life spans, including shifts in depth, a design element highlighted by several studies as having important implications for MPA networks for migratory species that depend on geographically separated critical habitats (Hyrenbach et al., 2000; Gerber et al., 2005; Hooker and Gerber, 2005; King and Beazley, 2005; Silva et al., 2012). For example, in the Glover's Reef Marine Reserve in the Caribbean Sea, two critical habitat areas for sharks are bisected by an exposed reef crest, which the sharks must routinely traverse and be exposed to fishing pressure (Chapman et al., 2005). Similarly, analysis of the distributions of bottlenose dolphin in the Gully MPA in Atlantic Canada suggested the shape of the MPA should be based on bathymetry (Hooker et al., 2011). Thus, shape considerations are intricately important for ensuring within-habitat connectivity for migratory species.

2.5 DISCUSSION

Well-designed MPAs can make effective contributions towards the conservation of migratory marine species and are thus a key tool in their conservation. However, the likelihood that some component of the life history of these species will occur outside the boundaries of any single or isolated MPA means that adequate conservation depends on the establishment of MPA networks, in conjunction with other non-place-based management strategies outside of their boundaries (O'leary et al., 2018; White et al., 2017; Game et al., 2009). MPA networks should provide an essential foundation for the management mosaic for migratory pelagics, as they deliver benefits that other tools cannot, such as the long-term protection of unique and vulnerable habitat features and climate change resilience and buffering against uncertainty in management and environmental change (Roberts et al., 2017). Evaluating the potential capacity of MPA networks to protect migratory pelagics in a context of climate change requires the consideration of several factors. These include species-specific life history characteristics and spatial patterns, criteria for ecologically-effective MPA and MPA network design derived from the IUCN guidance and relevant scientific literature, and the conservation objectives, management practices and governance arrangements of the MPA network in question.

2.5.1 Defining MPAs, MPA 'networks' & MPA 'systems'

In the literature MPA networks and MPA systems are often used interchangeably despite important differences. It is likely that this inconsistency on the part of researchers stems from misinterpretations and/or lack of clarity within IUCN and other definitions of MPA networks. While the 2008 IUCN definition defines an MPA network as a group of MPAs that "…operates cooperatively and synergistically…" (IUCN-WCPA, 2008, p 111), it does not explicitly identify the need for connectivity, nor does it distinguish the difference between systems and networks. Further, as some have argued, the IUCN definition is open to interpretation. For example, Grorud Colvert et al. (2014) defined five different types of 'networks' (ad hoc or regional, conservation, management, social, and connectivity), and argued that regardless of the type, population connectivity is an integral component and should be a fundamental goal of network design and establishment. Interestingly, an ad hoc or regional network, defined as a group of MPAs in proximity to each other but not planned as a synergistic network (Grorud-Colvert et al., 2014), is a contradiction to the IUCN definition which specifically requires MPA networks to work synergistically.

According to UNEP-WCMC (2008), an MPA network is a group of MPAs that are specifically planned as 'connected' systems; and, accommodating 'connectivity' is one of the defining features of MPA 'networks'. In contrast, Agardy and Wolfe (2002) argue that MPA 'systems' are sets of systematically selected MPAs that are planned and managed to achieve particular objectives related to the whole set. Using this distinction, a more accurate term for the arrangement of MPAs in an ad hoc or regional grouping, as defined by Grorud-Colvert et al. (2014), would be an MPA system. For example, an 'MPA system' can be composed of individual MPAs that have been systematically selected to ensure a representative selection of every bioregion, and thus are working synergistically to fulfill an objective, despite having no connectivity between them.

It is critical for communication, and especially to evaluations of the effectiveness of MPA networks to conserve migratory species, that the distinction between these two concepts is reinforced and maintained within the international guidance and the scientific literature. Given that the IUCN provides the definition of an MPA network that is most globally recognized by marine managers, the fact that it's lack of clarity may ultimately influence conclusions about their effectiveness for conservation is significant. Further, ambiguity in the use of these terms has been reproduced in international gatherings endorsing the global need for MPA networks; Aichi Target 11 in the Strategic Plan for Biodiversity states that by 2020 at least 10% of coastal and marine areas, especially areas important for biodiversity, will be conserved through *well connected* protected area *systems* [emphasis added] (SCBD, 2010). Fortunately, more recent IUCN guidance, such as Worboys et al. (2016), addresses this distinction in its calls for connectivity conservation areas, and this refinement should be emphasized and incorporated into refined MPA network design guidelines, as well as taken up within the literature.

2.5.2 Considering IUCN's ecological design guidelines in the context of the broader IUCN guidance for establishing resilient MPA networks

The IUCN ecological design guidelines are meant to serve as a general framework for MPA design, rather than for management, and to accommodate a wide variety of species, not all of which are migratory. Consequently, the IUCN's ecological guidelines do not include aspects of international management. However, these guidelines comprise only a single chapter of the IUCN report, and broad-scale considerations, best practices, and implementation strategies are addressed in the seven other chapters (IUCN-WCPA, 2008). For example, chapter three explicitly addresses the importance of institutional governance and trans-boundary MPA networks for cooperative management, and chapter four provides an extensive discussion of adaptive management measures (IUCN-WCPA, 2008, p 20).

International management – As the IUCN's ecological guidelines and many of the studies in the literature acknowledged, migratory species have movement patterns that take them through the waters of multiple nations and into areas beyond national jurisdiction (ABNJ). If MPA networks are to ensure the effective protection of migratory pelagics across their full distributions, it is thus essential to establish a mechanism for international cooperation in their design and management (Augustowski and Palazzo, 2003; Hoyt, 2009; Hooker et al., 2011; Lascelles et al., 2014; Geijer and Jones, 2015 (e.g., Hyrenbach et al., 2000; Hooker and Gerber, 2004; Hazen et al., 2013; Lascelles et al., 2014; Notarbartolo Di Sciara et al., 2016). This presents a significant challenge, as it requires coordinated action by many nations, international organizations, and other stakeholders, and legal tools and mechanisms to designate, manage, and enforce MPAs on the high seas do not currently exist.

No single management body has the authority to establish MPAs or to regulate access to and use of an area for more than one purpose in the high seas. The current management framework for ABNJ consists of a multitude of single-sector bodies responsible for managing ocean resources and human activities (e.g. the International Maritime Organization (IMO) has authority over shipping, while the International Seabed Authority regulates mining activities) (Geijer and Jones, 2015; Game et al., 2009). For example, the Pelagos Sanctuary, located partly in the national waters of France, Monaco, and Italy and partly in the high seas, could be viewed as a model for international cooperation in the management of a high seas MPA; however, its effectiveness for cetacean conservation has been severely undermined by the lack of an empowering management structure and the absence of mitigation measures to adequately address threats posed by fishing, shipping, and coastal development (Geijer and Jones, 2015). The lack of a legal framework for making and enforcing MPA designations in international waters means that migratory species remain vulnerable to threats across a significant proportion of their migratory range, thereby limiting the potential of MPA networks to effectively conserve these species. International cooperation among all nations and authorities along the same migration route is therefore essential.

The UN General Assembly has called for the development of an international legally-binding instrument under UNCLOS to address the conservation and sustainable use of biodiversity in ABNJ, one potential goal of which is to establish a framework for implementation of MPAs on the high seas (Notarbartolo Di Sciaro et al., 2016; Davies et al., 2017; Boerder et al., 2018). Such an instrument presents an opportunity to lay the foundation for a more integrated and cross-sectoral system of governance in ABNJ that takes into account both biodiversity conservation and sustainable use. However, given that preparatory negotiations are ongoing, its overall benefits are largely unknown.

Adaptive management – The IUCN guidance and studies in the literature recognize that the conservation of migratory pelagics within MPA networks can benefit from adaptive management. It is useful in response to (i) ongoing and anticipated ecosystem changes and species range shifts in response to climate change (Hooker et al., 2011; Hobday 2011; ICES, 2011; Lascelles et al., 2014), (ii) the need for monitoring of conditions within and outside the MPA, especially in relation to the status of the focal species and their exposures to threats (Hinch and De Santo, 2011; Hooker et al., 2011; Hobday, 2011; Mullen et al., 2013), and (iii) the need for a precautionary approach, which ensures that data limitations or lack of full knowledge do not preclude proactive action to reduce the risks posed to migratory species and their habitats (Game et al., 2009; Hoyt, 2009; Hinch and De Santo, 2011; Davies et al., 2012; Worboys et al., 2016). In light of current and impending climate change, it is essential that MPA network design and planning adopt precautionary approaches to alleviate the burden of proof; full scientific certainty of impacts on migratory species should not be required before protective action is deemed justified.

The incorporation of dynamic MPAs into MPA networks is identified in both the literature and the guidelines as an important adaptive strategy for ensuring long term protection, particularly given anticipated climate induced range shifts of many species. Further, the spatial movements of many migratory species are targeted at transient oceanic features such as frontal regions and areas of upwelling, both of which are critically important during particular life history stages, such as breeding or feeding, but are limited in use to only a few days, weeks, or months each year (Hyrenbach et al., 2000; Hazen et al., 2013; Lascelles et al., 2014). Thus, the incorporation of dynamic boundaries within

MPA networks is particularly necessary for such migratory pelagics whose critical habitats are neither static nor temporally persistent.

The implementation of dynamic MPAs is in its infancy, and thus empirical evidence for their effectiveness does not yet exist (Reeves, 2000; Game et al., 2009; Gruss et al., 2011; Hooker et al., 2011; Davies et al., 2012; Notarbartolo di Sciara et al., 2016). However, conceptual advances in technology and satellite observations have made dynamic MPAs a viable conservation strategy (Game et al., 2009; Davies et al., 2012; Lascelles et al., 2014). Notarbartolo Di Sciaro et al. (2016) argue that, given their heightened dependence on oceanic variability, foraging areas are likely to undergo major shifts in location, thus making these areas appear particularly suitable for dynamic protection. While Notarbartolo Di Sciaro et al. (2016) argued that foraging areas are particularly suited for dynamic protection given their dependence on oceanic variability and resulting likelihood of undergoing major shifts in location, other studies identified the potential use of dynamic MPAs for protecting species movement corridors, which have been severely neglected in the conservation of migratory species to date (Hooker et al., 2011 and Mullen et al., 2013). According to Mullen et al. (2013) it is the fact that animals tend to spend little time within migratory corridors that makes these habitats particularly suitable for dynamic protection. Hooker et al. (2011) argue that movement corridors could be protected via dynamic MPAs targeted at predictable habitat features, and cites the temperate fronts that delineate the migratory routes of loggerhead turtles in the central Pacific as one viable example. Despite the fact that corridors may contain low densities of species at any one time, their protection is essential for maintaining the functional linkages between seasonal residence critical habitat areas and preventing habitat fragmentation (Mullen et al. 2013).

Guideline three calls for the development of dynamic MPAs and MPA networks for highly migratory species that ensure protection of critical lifecycle stage habitats both spatially and temporally, depending on the season of use (IUCN-WCPA, 2008). Some authors argue that the total area required for effective protection using dynamic MPAs is likely to be less than that for static MPAs (Game et al., 2009; Gruss et al., 2011; Hooker et al., 2011; Mullen et al., 2013; Maxwell et al., 2015; Boerder, 2018), since the former can be directed to a few critical habitat areas, and can adjust their boundaries as species move, or in response to, for example, the impacts of climate change, or mistakes made in employing the precautionary principle. However, periodic protection through dynamic MPAs will be less effective than permanent MPAs and thus the IUCN guidance suggests they should only be used in response to specific socioeconomic characteristics and when permanent MPAs are politically unrealistic. Understandably, the IUCN leaves the specific socioeconomic characteristics that justify dynamic MPAs, or the circumstances under which permanent protection would be deemed unrealistic, to the discretion of nation states. However, this discretion detracts from its practical value in guiding decision makers and risks ineffective protection from threats in favour of socio-economic or political pressures.

Despite the fact that dynamic approaches are likely to be important tools in the migratory pelagic species conservation toolbox, they cannot be considered ‘protected areas’, per se, if they do not confer long term protection as defined by the IUCN; ‘dynamic MPAs’ is a contradiction in terms, or an oxymoron. This contradiction becomes even more confusing given that IUCN guidance itself calls for the establishment of ‘dynamic MPAs’

(IUCN-WCPA, 2008). Thus, in order to avoid further terminological confusion, it may be advisable to refrain from referring to them as PAs, and instead call them dynamic marine areas, dynamic marine conservation areas, or some other such term. This should help clarify important distinctions between the terms, and in particular, help defuse disagreements that arise from concerns around the lack of long-term protection associated with such dynamic areas. For clarity in governance, management, and reporting, the term MPA should be reserved for areas that meet the IUCN definition of a 'protected area' under Aichi Target 11.

2.6 CONCLUSIONS & RECOMMENDATIONS

This review has (i) assessed the degree to which the five IUCN ecological guidelines for designing effective MPA networks addressed the conservation of large migratory at-risk pelagic species, (ii) discerned similarities and differences between the IUCN guidelines and the scientific literature in how each guideline and its strategies were conceptualized and discussed, and (iii) identified additional ecological themes that emerged from the literature as relevant for the conservation of migratory pelagics within MPA networks that are not being adequately addressed by the guidelines.

In general, each guideline would benefit from an explicit explanation of its relevance and application to migratory pelagics, given their functional (trophic-regulating) role in marine ecosystems, vulnerable status, and large-area and wide-ranging habitat requirements, all of which situate them as important focal species for ecologically effective MPA network design. Many of the 2008 IUCN guidelines are too broad to be of practical use for these species' groups, and specific examples and recommendations for the application of the guidelines tend to be biased towards fisheries management and commercially exploited species. Further, more meaningful considerations of the influence of climate change and other environmental disturbances on MPA network design characteristics is warranted. While studies in the literature generally reflect most themes in the IUCN guidelines, they do not adequately address the importance of spacing, shape, and the protection of migration routes as considerations in MPA network design.

Despite being adequately addressed in the IUCN guidelines, particularly guidelines two and four, the largest identified gap in the literature was the attention to the protection of migration routes within MPA networks; less than half of the assessed studies included any discussion of the protection of migratory habitat. The lack of such discussions may be linked to the pre-conceived notion that it would be politically unfeasible to protect migratory routes given their expansive size and the fact that migrations often occur in pelagic areas which are more difficult to access and monitor. Nonetheless, closing such gaps is critical, and until equal consideration is given to protecting all critical habitat areas, including migratory pathways, MPA networks are likely to prove ineffective for maintaining or recovering populations of highly migratory species.

The failure to protect migratory pathways is likely also a symptom of the larger challenge of effective international management. Given the IUCN guidelines and the considerations revealed in the assessed literature, it is clear that MPA networks of very large spatial extents are required to effectively conserve migratory pelagic species. Accordingly, the need to foster international collaboration and management is critical. This may well be the most serious obstacle currently facing the establishment and management of MPA networks, as we lack the policy and other tools necessary to take action in ABNJ. While the development of the UNCLOS ABNJ instrument presents a promising solution, it is likely years away from implementation. Thus, in the meantime it will be important to continue with efforts to foster collaboration across national borders.

For more effective communications and partnerships in marine conservation, greater clarity and consistency around the use of key terms is warranted, recognizing the influence of language on collaboration (Agardy et al., 2003; Beazley et al., 2010). The term MPA should apply solely to those areas that meet the IUCN definition of 'protected area' and other terms should apply to those areas that do not meet the definition, while recognizing that they also may provide conservation benefits. Further, there is a need to adopt consistent definitions that distinguish between 'systems' and 'networks', with 'networks' being used exclusively when connectivity is an integral component. Thus, MPA networks for migratory species would, by definition, include migratory 'pathways' in their design and protective measures. Such clarity and consistency in definitions are important to assessing the effectiveness of MPA networks and should lead to greater consensus on their potential utility for migratory species. Further, the lack of a consistent language, typology and conceptual framing in reference to MPAs, MPA systems, and MPA networks has significant implications for management, as divergent meanings in core concepts have been found to impede and undermine collaborative efforts, especially when the work being done has implications for public policy (Hall et al., 1997; Lindenmeyer and Fischer, 2006; Beazley et al., 2010). Thus, given the current push to reach the goals set by Aichi Target 11, and the UN initiative for conserving biodiversity in ABNJ, addressing the challenge of consistent meaning and use of core concepts among IUCN guidance and other experts involved in marine conservation planning is essential.

There is a clear need for increased focus on science, planning, design, establishment and management of MPA networks for large migratory at-risk pelagics in the context of climate change. Our research showed that MPA networks are widely agreed to be potentially effective if well designed and established and are likely to be the best and only way to safeguard these species. There are gaps in scientific knowledge around key aspects, such as migratory routes, that warrant immediate attention. The urgency of the situation requires increased national and international efforts, based on collaborative and precautionary approaches, adaptive management/planning frameworks, and utilizing a mix of protection mechanisms, from large no-take to dynamic areas, across terrestrial and marine. To support such efforts, updates to the 2008 IUCN ecological guidelines are needed that incorporate a revised definition of MPA 'network' to explicitly include 'connectivity', large migratory at-risk pelagics as focal species, migratory routes as important components, and implications of climate change for spatial distribution and extent of species and habitat requisites. Updates to the broader IUCN guidance around MPA network governance and management considerations are warranted around adaptive and dynamic planning frameworks and international collaborations, as critical contexts.

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CHAPTER 3: ASSESSING THE CAPACITY OF MPA NETWORKS FOR CONSERVING MIGRATORY PELAGICS REQUIRES A CLARIFICATION OF THE TERMS 'MARINE PROTECTED AREA' AND 'NETWORKS'

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Abstract: Populations of several charismatic migratory pelagic species, such as sharks, sea turtles, and marine mammals, are facing wide-scale population declines. While research suggests that networks of marine protected areas may be able to effectively conserve migratory pelagics, there is a significant polarization of views amongst members of the marine conservation community. In this study, we assess local expert judgments, derived from in-depth individual interviews, on the potential effectiveness of MPA networks for highly migratory pelagics. The majority of experts expressed limited support for their effectiveness (i.e. effectiveness depends on a species particular life history characteristics), and identified five essential design and management characteristics for effective MPA networks: (1) connectivity; (2) protection of critical habitat; (3) adaptive management; (4) complementary management; and, (5) international collaboration and management. Analysis of expert judgements revealed the following challenges that are limiting the effectiveness of MPA networks for migratory pelagics: (1) the lack of distinction made amongst experts and international guidance between MPA systems and MPA networks; (2) a lack of clarity around what constitutes an 'MPA' globally; and (3) uncertainty regarding the ability of MPA networks to provide the dynamic management required for migratory pelagics, and inversely, the ability of 'dynamic' MPAs to provide long term 'protection'.

Keywords: marine protected area network, MPA system, IUCN, Aichi Target 11, connectivity, expert interviews

3.1 INTRODUCTION

Declines in biodiversity from human-induced stressors have prompted accelerated establishment of marine protected areas (MPAs) intended to promote the long-term conservation of biodiversity (Agardy et al., 2003). MPAs have predominately been used to protect organisms of limited motility, their habitats, and the ecosystems they may form. Recently, however, the potential effectiveness of MPAs and MPA systems and networks for conserving wide-ranging pelagic species is being questioned. Populations of charismatic migratory pelagic species, such as sharks, sea turtles, and marine mammals, are facing wide-scale declines, due primarily to intentional and unintentional catch (i.e. bycatch) during harvesting of aquatic resources (Lascelles et al., 2014, Schipper et al. 2008). Global changes, such as those associated with climate change, are also likely to negatively impact migratory species through loss of habitat, reduced ocean productivity, shifts in location of prey, habitat shifts due to changes in ocean currents and sea surface temperature, or direct mortality (CMS, 2008; Lascelles et al., 2014). In turn, declines in migratory pelagics will likely negatively affect marine ecosystems because of their significant role in regulating ecosystem structure, function and dynamics (Ceccarelli et al., 2014; Scott et al., 2012; Geijer and Jones, 2015; Graham et al., 2016; King and Beazley, 2005).

The dynamic spatial and temporal scales associated with migratory species and their pelagic environment present challenges for their conservation relative to that of sessile organisms. Single, isolated MPAs, regardless of size, cannot ensure viable, self-sustaining populations of these highly motile species, as individuals will migrate outside the protected area boundaries. Consequently, focus has shifted from individual MPAs to well-connected

MPA networks. A MPA 'network' is defined by the IUCN as, "a collection of individual marine protected areas that operates cooperatively and synergistically, at various spatial scales, and with a range of protection levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could alone" (IUCN-WCPA, 2008). If well-designed, MPA networks can contribute to the conservation of migratory species through the protection of critical habitats and the marine areas that connect them (Hooker et al., 2011; Dudley et al., 2018; Smith and Metaxas, 2018). The design of an MPA network that is appropriate for the protection of migratory species throughout their life cycles has been identified as a top research priority (Dudley et al., 2018).

Despite this focus, the effectiveness of MPA networks for conserving highly migratory marine pelagics remains contentious (see, for example Reeves, 2000; Game et al., 2009; Hinch and De Santo, 2011; Hooker et al., 2011; Boerder 2018). A recent review identified a clear need for increased focus on design, establishment and management of MPA networks for large migratory at-risk pelagics in the context of climate change (Allan, Beazley & Metaxas, 2019, unpublished manuscript). Further, there is a general call for more expert engagement in conservation planning (Martin et al., 2005; 2012; Grêt-Regamey et al., 2013), given the multiple benefits that arise from engaging experts, including enhanced legitimacy, increased support, and the incorporation of local, tacit knowledge. Expert interview studies are typically based on a group of intentionally selected individuals who possess expert knowledge of the subject matter under study rather than a randomly selected sample (Laws et al., 2004, Otto and Österle, 2010). In this study, we assess expert judgments derived from in-depth individual interviews on the potential effectiveness of MPA networks for highly migratory pelagics and identify points of commonality and discord. Local-regional experts with knowledge specific to the North Atlantic were interviewed. We (1) identify approaches for reconciling conflicting perceptions, and (2) propose a refinement of the concept of MPA networks that will improve its practical application and forward an agreed common language, all of which are critical for collaboration and moving towards more effective protection of migratory pelagics.

3.2 METHODOLOGY

3.2.1 Recruitment and Participants

In this study, ‘expert’ is defined as an individual with experience and extensive knowledge of at-risk, large, marine pelagics native to the Northwest Atlantic, and/or ocean conservation planning in the region. Of 30 experts contacted, 17 academic researchers, activists, and government managers agreed to participate, from government (n=4), non-government (n=4), and academic (n=9) sectors (Table 7)[1], giving this study a return rate of 56.6%. This sample size represents a large proportion of relevant experts and subsequent analyses of the data show that it achieves data saturation (Morse et al., 2002; Guest et al., 2006; Morse et al., 2014) for our delimited scope. Because of their relative positions at the center of marine conservation planning and policy, the perspectives of these experts can be expected to have substantial impact on the design, establishment, and overall effectiveness of MPA networks for migratory pelagics.

[1] Industry-specific experts declined to participate. Indigenous participants were not specifically targeted due to the time required to foster relationships of trust and follow Indigenous research ethics, principles and practices.

Table 7: Affiliation of experts interviewed in this study

	Expert Affiliation	Number of Experts Interviewed
Academic Researchers	Dalhousie University, Halifax, NS	6
	Duke University, Durham, NC	1
	Memorial University of Newfoundland, St. John’s, NL	1
	University of Victoria, Victoria, BC	1
ENGO Employees	Canadian Sea Turtle Network, Halifax, NS	1
	IUCN, Cambridge, MA	1
	World Wildlife Fund, St. John’s, NL; Halifax, NS	2
	Deep Sea Conservation Coalition, Halifax, NS	1
Government Managers	Fisheries and Oceans Canada, Halifax, NS	3
Total		n = 17

3.2.2 Data collection and analyses

Semi structured interviews also the comparison of among participants (Appendix D) while also providing sufficient interviewer flexibility to follow up on areas of particular relevance to each expert. The questions entailed establishing definitions and examining perspectives on the potential effectiveness of MPA networks for migratory pelagic species. Interviews ranged from 30 to 120 minutes in duration, and were conducted in person or face-to-face on line (i.e. Skype) and audio recorded, between July 2017 and February 2018.

Audio recordings were transcribed verbatim and thematically coded in NVivo text analysis software. *A priori* codes were pre-determined from key definitions and considerations identified from a review of the MPA literature (Table 2) and applied deductively to the transcripts to identify phrases associated with the codes. *A posteriori* codes emerged from close readings of the transcripts, reflecting an inductive approach to the data (Table 8). In the first round of coding, key words and phrases were coded, and in subsequent rounds, conceptually related terms/phrases were synthesized as "child-nodes", or "grand-child nodes" under broader "parent-node" codes/categories. Coding served to organize the 'bits' of interview data (i.e. words, phrases, sentences) into a hierarchical framework of themes and sub-themes for further analyses to identify commonalities, differences and explanatory relationships. Analyses served to synthesize experts' opinions by identifying: key themes that recurred frequently across interviews; minority themes that, although seldom expressed, represented useful findings given their contrast to views expressed by the majority; nuanced commonalities and differences across expert perspectives; important relationships among and across themes; and, explanatory reasons for them.

Table 8 –A priori codes identified from literature and a posteriori codes that emerged from interview data, organized based on a hierarchical relationship into parent nodes (themes), child nodes (sub-themes), grand-child nodes (sub-sub-themes). *A posteriori* codes identified with *

Parent Node	Child Node	Grand-child Node
Design factors	Size, shape, spacing	
	Connectivity	
	Critical habitat protection	
Biological factors	Site fidelity	Fidelity to critical habitat areas *
	Migrations	
	Home range	
	Data limitations *	
Management/governance factors	International management	Sectoral management (RFMOs) * Cross-sectoral management (UN BBNJ) *
	Adaptive management	Precautionary approach *
	Complementary management	
Political factors *	Stakeholder pushback *	
Climate change	Species shifts	
	Loss of habitat	

	Data limitations*	
Conceptual inconsistencies	Marine protected area (MPA)	IUCN definition *
	MPA 'network'	IUCN definition*
	MPA 'system'	
	Dynamic ocean management	Real time management *
		Dynamic MPAs *

3.3 RESULTS

Three main results were distilled from the interview analysis:

1. Most experts agree that MPA networks have the potential to provide effective conservation for highly migratory pelagics;
2. There was a high degree of agreement amongst experts on the necessary design and management characteristics of an effective MPA network for highly migratory species; and,
3. Differences exist in expert definitions and interpretations of fundamental or core concepts as represented by key terminology in marine conservation (i.e., MPA, MPA 'network', and MPA 'system').

3.3.1 MPA networks have potential as an effective conservation strategy

Most experts agreed that MPA networks have the potential to effectively contribute to the conservation of highly migratory pelagic species. The strength of this support varied, however, with strong support demonstrated by 6 experts, limited support by 10, and no support by 1 (Appendix E). Strong support for the effectiveness of MPA networks was based on their overall role for all migratory species. In contrast, the experts that expressed limited support were concerned that MPA networks would only benefit migratory species with particular life history characteristics. These experts recognized that there is a range of migration distances in highly migratory pelagic species and argued that protection of the widest ranging of these species (i.e. those with the longest migrations) would be challenging within MPA networks. Some argued that MPA networks would only be effective for those species exhibiting evidence of site fidelity, such as leatherback turtles who demonstrate fidelity to spawning areas and nesting beaches. Interestingly, the single expert that did not express support for MPA networks argued that the expansive annual migrations of species such as leatherback turtles make MPAs designed for their conservation unfeasible.

3.3.2 Characteristics of effective networks for migratory species

The experts who supported the utility of MPA networks for conserving migratory pelagics identified the same five essential characteristics for effectiveness: (1) connectivity; (2) protection of critical habitat; (3) adaptive management; (4) complementary management; and, (5) international collaboration and management.

3.3.2.1 Design characteristics

Experts (n=16) indicated that effective MPA networks must facilitate or preserve connectivity among critical habitat areas and throughout the lifecycle of migratory species. In such responses, experts spoke of connectivity in terms of the protection of migratory routes between critical life requisite sites, either as corridors or stepping stones. Critical habitat areas mentioned by experts include those for foraging, breeding, nesting, migratory routes, nursery, spawning, and mating. Foraging habitat was identified as important to include by all but one expert (n=15). Most experts highlighted the importance of protecting spawning areas (n=12) and breeding habitats (n = 8), while the remaining critical habitat areas (i.e. nursery, migratory routes, nesting, and mating) were mentioned by less than half of the experts.

According to some experts (n=7), the ability to effectively identify and protect critical habitat is influenced by species-specific site fidelity, a form of philopatric behavior (Jorgensen et al., 2009; Chapman et al., 2015). Experts argued that certain migratory species appear to show site fidelity to particular habitat locations, regularly aggregating in the same fairly restricted areas at predictable times every year. Accordingly, the experts argued that migratory species exhibiting this behavior are easier to protect within MPA networks, while those lacking this trait are unlikely to benefit as much from spatial protection through MPAs.

3.3.2.2 Management characteristics

Most experts argued that effective MPA networks for migratory pelagics must include (1) adaptive management strategies, (2) complementary management approaches, and (3) international collaboration. As defined by the IUCN, adaptive management "enables a flexible and timely decision structure that allows for quick management responses to new information about, or changes in, ecosystem conditions…" (IUCN-WCPA, 2008). Experts pointed to projected shifts in distributions and key habitats for migratory pelagics with changing oceanographic conditions due to climate change as the main impetus for adaptive management. For example, recent changes in distribution of the North Atlantic right whale in response to warming waters and resultant changes in the location of their food supply and foraging habitats was identified as demonstrating the need for adaptive management. Such shifts expose migratory species to new threats, and as a result, experts insisted that adaptive management is essential to MPA network effectiveness for migratory pelagics; adaptive management allows for adjustments to MPA boundaries in response to changes in their distribution.

Two approaches were frequently cited by experts with respect to adaptive management: the precautionary approach, and dynamic ocean management. Most experts indicated dynamic ocean management as an adaptive strategy that should be incorporated into MPA networks for migratory pelagics. While MPAs have traditionally been static tools with geographically set boundaries, experts advocated for dynamic MPAs with coordinates that shift in response to changes in species locations, movements, and habitat. According to these experts, dynamic management is particularly relevant for migratory species, not only because of climate-change-induced shifts in species distributions, but also because pelagic habitats are dynamic in nature and thus not suitable for static protection.

According to the Convention on Biological Diversity (1992), the precautionary principle, or precautionary approach, states that "where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat". Several experts alluded to the need to be precautionary in selecting the areas to be protected as MPA networks for migratory species, particularly in light of climate change. More specifically, experts focused on the need to not only protect those areas that a species is currently using, but also those areas it may inhabit in the future. Two experts referred to this process of designating areas that might offer critical habitat in the future as "future-proofing" protected areas (personal communication, Boris Worm, 07-18-2017; personal communication, Samantha Andrews, 10-12-2017).

Most experts agreed that MPA networks alone would not be sufficient to achieve effective long-term protection for migratory pelagics, arguing that complementary management approaches must also be implemented. They suggested that migratory species would inevitably spill outside the boundaries of a MPA network, and that therefore the effectiveness of any MPA network would be enhanced when used in conjunction with non-place-based fisheries management strategies beyond MPA boundaries, such as bycatch quotas, gear restrictions, and temporary closures.

All experts recognized that the movement of migratory species beyond areas of national jurisdiction during their lifecycle necessitates international cooperation and management of MPA networks. The majority acknowledged that achieving cross-sectoral cooperation to establish and manage high seas MPAs is critical, yet particularly challenging, as there is currently no mechanism in place that enables the implementation of such MPAs. The current management landscape in areas beyond national jurisdiction (ABNJ) is fragmented, and management is determined regionally and by each individual sector. For example, the International Maritime Organization (IMO) has authority over shipping, the International Seabed Authority regulates mining activities, and regional organizations are responsible for fisheries management. However, several experts referenced the UN Biodiversity Beyond National Jurisdictions (BBNJ) instrument, currently under development, and expressed optimism about its ability to provide this function in the future. Indeed, two experts referred to it as the most promising opportunity for marine conservation at this point in time.

3.3.3 Defining core concepts – IUCN vs. Experts

Throughout the interview process, experts were asked to provide definitions for two terms: marine protected area, and marine protected area network (Appendix F). The IUCN provides definitions for both: a marine protected area is "a clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Day et al., 2012); and, an MPA network is "a collection of individual marine protected areas or reserves that operates cooperatively and synergistically, at various spatial scales, and with a range of protection levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could alone" (IUCN-WCPA, 2008). UNEP-WCMC (2008) also provides a definition of an MPA network, defining it as a group of MPAs that are specifically planned as 'connected' systems; as such, accommodating 'connectivity' is one of the essential characteristics of MPA 'networks'.

Nearly half of the experts (n=7) included all components of the IUCN definition of an MPA within their own definition (Table 9). In general, most experts defined "marine protected area" as a geographic area of the ocean that is actively managed for the purpose of achieving a specific conservation objective. All experts (n=17) included 'geographical space' as a component of their definition, followed closely by 'managed' (n=16) and 'long-term conservation of nature' (n=12). The remaining five elements of the IUCN definition (i.e. "clearly defined", "recognized", "dedicated", "managed", "legal or other effective means", and "to achieve") were mentioned by fewer than half of the experts. While eight experts referenced the IUCN definition specifically, most of them were unable to recall all of the components of the definition; however, their reference to the IUCN presumably indicates support for the definition and its various components.

Table 9: Matrix depicting coverage of IUCN MPA definition components (Day et al., 2012), within expert definitions. A detailed description of each component is provided by IUCN (2008), and a summary table can be found in Appendix E (Day et al., 2012).

Expert	IUCN 'MPA' Definition Components							
	Clearly defined	Geographical space	Recognized	Dedicated	Managed	Legal or other effective	… to achieve	Long-term conservation of nature
1		X			X			
2		X			X			X
3	X	X	X	X	X	X	X	X
4	X	X			X			X
5		X			X			
6		X			X			
7	X	X	X	X	X	X	X	X
8		X	X	X	X			
9		X	X	X		X		X
10		X			X			X
11	X	X	X	X	X	X	X	X
12	X	X	X	X	X	X	X	X
13	X	X	X	X	X	X	X	X
14	X	X	X	X	X			X
15	X	X	X	X	X	X	X	X
16		X			X			X
17	X	X	X	X	X	X	X	X
Total	n = 8	n = 17	n = 7	n = 7	n = 16	n = 6	n = 4	n = 12

Table notes: Numbers are used to represent experts in effort to preserve confidentiality.

Several experts expressed difficulty when asked to define a "marine protected area", attributing this to a linguistic misunderstanding of the term resulting from the diversity of definitions across local, national and international contexts, and inconsistent uses of the term. Experts acknowledged that such misunderstanding can create "unspoken expectations" (personal communication, Sean Brillant, 10-18-2017) among stakeholders, which can, in turn, hinder effective communication and collaboration. For example, experts attributed the high level of stakeholder pushback against MPAs as a result of the tendency amongst this group to ignore the nuance of the IUCN PA classification system and assume that all proposed MPAs will be marine reserves, and thus exclude any and all extractive uses. Overall, experts argued that the lack of consistency in the definition of a marine protected area used by different sectors is largely the result of (i) the number of different protected area management categories outlined by the IUCN, (ii) the differences in how the term 'MPA' is applied across various contexts, and (iii) how a 'marine protected area' differs from or is the same as 'other effective area-based conservation measures' (OEABCMs) outlined in the CBD Aichi targets.

While OEABCMs were referenced by five experts during their interviews, none provided a definition for, or elaborated on what would be considered, an OEABCM. However, all experts did acknowledge the importance of distinguishing OEABCMs from MPAs. Indeed, two experts only referenced OEABCMs when asked to provide their definition of an MPA, arguing that the introduction of OEABCMs was a contributing factor to the vagueness of the MPA definition. For example, one such expert discussed the "grey line" that exists between what constitutes an MPA on the one hand and what constitutes an OEABCM on the other (personal communication, David VanderZwaag, 10-11-2017). While one expert spoke positively about the OEABCM mechanism, stating that it provided a faster channel for area-based protection compared to the establishment of MPAs, and thus would assist countries in meeting their conservation targets, two experts argued that rushing to meet such targets through the implementation OEABCMs at the expense of MPAs represented an approach that favors the quantity over quality of protection.

Similar inconsistencies among experts arose surrounding the definition of a "marine protected area network". In this case, only a single expert (#7) mentioned all of the IUCN definition components within their definition (Table 10). Most experts referenced three components of the IUCN definition: that marine protected area networks are a collection (n=15) of individual MPAs (n=14), that are designed to operate cooperatively and synergistically as a whole (n=14). Very few experts mentioned the remaining five components of the IUCN definition ("…or reserves", "various spatial scales", "range of protection levels", "fulfill ecological aims", and "more effectively and comprehensively than individual sites could alone"). Only one expert recognized that MPA networks consist of a range of protection levels, and three acknowledged that the networks can be composed of more than MPAs, including things such as reserves, sanctuaries, and non-Oceans Act MPAs[2].

Table 10: Matrix depicting coverage of IUCN MPA network definition components, taken from Day et al. (2012), within expert definitions.

Expert	IUCN 'MPA network' Definition Components							
	Collection	Individual MPAs	… or reserves	Operate cooperatively & synergistically	Various spatial scales	Range of protection levels	Fulfill ecological aims	More effectively & comprehensively than individual sites could alone
1	X	X					X	X
2	X	X		X				X
3								
4	X	X		X	X		X	
5	X		X	X				
6	X	X		X				
7	X	X	X	X	X	X	X	X
8	X	X		X				

[2] Section 35.1 of the Canadian Oceans Act states that, "a marine protected area is an area that forms part of the internal waters of Canada, the territorial sea of Canada, or the EEZ[2] of Canada, and has been designated under this section for special protection…" (DFO, 2016).

9	X	X		X				
10	X	X		X				
11	X	X		X				
12	X	X	X	X				
13	X	X		X				
14	X	X		X			X	X
15	X	X		X			X	X
16								X
17	X	X		X	X			
Total	n = 15	n = 14	n = 3	n = 14	n = 3	n = 1	n = 5	n = 6

Table notes: Numbers are used to represent experts in effort to preserve confidentiality.

Two characteristics of MPA networks were mentioned by experts that are not explicitly addressed in the formal IUCN definition (IUCN-WCPA, 2008): (1) a network for migratory pelagics must be 'dynamic'; and, (2) a network must be designed around the principle of 'connectivity'. However, it must be recognized that, while the term 'connectivity' is not included in the IUCN definition, recent IUCN guidance does recognize the importance of protecting the interconnectedness between and within ecosystems, specifically addresses and establishes a clear definition of connectivity conservation areas (CCAs), and defines criteria for their international recognition (Worboys et al., 2016).

Nearly all experts agreed that a dynamic approach to the management of highly migratory species is essential for their effective conservation (n=16). These experts argued that dynamic management should be embedded within MPA networks through the establishment of either (1) 'dynamic MPAs' or (2) other dynamic areas that do not meet the definition of a protected area but nonetheless contribute to conservation. Experts supporting 'dynamic MPAs' described them as areas with designated positions that change as the locations of a species or habitat changes, and thus as representing a more seasonal and responsive approach to spatial management compared to traditional, static MPAs. In contrast, those that supported 'other' dynamic management areas explained that, while essential, any form of seasonal management fails to provide long-term protection, and thus cannot be considered an MPA as per the IUCN definition. However, these experts also argued that any effective MPA network would necessarily encompass complementary tools, including non-MPA dynamic and seasonal management areas.

Over half of the experts (n=10) explicitly identified 'connectivity' as a key component of MPA networks. Connectivity refers to the ecological linkages between individual MPAs within a network and can be divided into four distinct types: landscape, community, ecosystem, and population connectivity (Palumbi, 2003; Worboys et al., 2016; Balbar and Metaxas, 2018). Population connectivity is further divided into genetic and demographic connectivity (Balbar and Metaxas, 2018). While experts acknowledged that connectivity has multiple meanings in a marine context, the majority referred to demographic population connectivity, which entails the unimpeded movement of individuals and groups among critical habitat areas throughout their lifecycle. Other types of connectivity mentioned by experts included landscape connectivity, ecosystem connectivity, and genetic connectivity. Of the seven experts who did not specifically mention the word 'connectivity', most described MPA networks as groups of MPAs that are cohesively planned or ecologically linked, and one expert referenced the IUCN definition, describing MPA networks as a collection of MPAs operating cooperatively and synergistically. When these seven experts were subsequently asked to explain what connectivity meant in a marine context, most (n=5) referenced population connectivity.

Further, when asked what MPA networks are theoretically meant to protect, nearly half of these experts (n=3) stated that MPA networks are meant to protect migratory species and their critical habitats. Taken together, these statements show further support amongst experts for the function of MPA networks in providing connectivity, despite it not being directly referenced in their definitions. The single expert that did not support the effectiveness of MPA networks for the conservation of highly migratory pelagics also did not identify connectivity in their definition of an MPA network, or with respect to species movement.

3.4 DISCUSSION

Differences among experts' interpretations, definitions and distinctions between MPA systems and MPA networks was a primary factor in their judgements about the effectiveness of MPA networks for the conservation of highly migratory pelagics. Further, the range of marine management designations in use globally, and the varying definitions of each, that the IUCN attempts to encompass using the term 'MPA' contributes to a lack of consistency with regard to the interpretation and application of IUCN definitions and standards. Crucial to establishing clear definitions is the need to assess how the call for adaptive and dynamic MPAs for migratory species can be reconciled with the long-term protection requirement of the IUCN PA definition. This will in turn require a clear and consistent definition of other effective area-based conservation measures (OEABCMS) and guidance around which areas can count as PAs and OEABCMs under Aichi Target 11. The failure to abide by a common language in marine conservation is problematic in that it can (1) influence judgements on the effectiveness of MPA networks for the conservation of species that require population connectivity, (2) cause challenges for the broad collaboration required to conserve such species and establish MPA networks, across multiple boundaries and in various jurisdictions, globally, and (3) challenge the assessment of progress towards global conservation targets.

3.4.1 MPA 'network' vs. MPA 'system'

The lack of distinction made between, and the interchangeable use of, the terms MPA 'network' and MPA 'system' in internationally utilized definitions and gatherings endorsing the global need for MPA networks, are two possible contributing factors to the ambiguous and inconsistent application of both terms during expert interviews. Definitions of MPA 'system' are scarce within marine conservation literature. UNEP-WCMC (2008) references Agardy and Wolfe (2002) when distinguishing between MPA systems and networks, explaining that PA 'systems' are sets of systematically selected MPAs that are planned and managed to achieve particular objectives related to the whole set, whereas a 'network' refers to a group of MPAs that are specifically planned as 'connected' systems; and, accommodating 'connectivity' is one of the defining features of MPA 'networks' (Palumbi, 2003; Roberts et al., 2006; IUCN-WCMC, 2008). However, when designing a MPA network for the conservation of a migratory species, ensuring connectivity is of even higher importance, as connectivity is crucial to these species' access to life-history requisites such as feeding and nesting areas, dispersal, and immigration/emigration, all of which also facilitate a species' response to climate change (Lemieux et al., 2015). Despite this importance, the IUCN definition of an MPA network provides no explicit mention of the term connectivity, leaving its meaning vague and open to interpretation. As a result, the definition is theoretically applicable to both MPA systems *and* networks of MPAs, despite the important design differences between them. The IUCN definition does state that the individual MPAs and reserves comprising an MPA network must operate "cooperatively and synergistically" (IUCN-WCPA, 2008), meaning that the network must have an effect greater than that which could be expected from each individual MPA (i.e. that the whole is greater than the sum of its parts) (Botsford et al., 2009; Grorud-Colvert et al., 2014), but while some may infer that this requirement accounts for connectivity, others may not. For example, an 'MPA system' can be comprised of individual MPAs that have been systematically selected to ensure a representative selection of every bioregion, and thus are working synergistically, despite lacking connectivity between them. Thus, the vague wording within the definition leads to confusion, particularly given the scarcity of definitions that exist for MPA systems. Such confusion can have important implications for communication and the scale of collaboration needed to establish effective MPA networks for migratory pelagics.

Ambiguity in the use of these terms is further evident in international gatherings endorsing the global need for MPA networks; Aichi Target 11 in the Strategic Plan for Biodiversity states that by 2020 at least 10% of coastal and marine areas, especially areas important for biodiversity, will be conserved through *well connected* protected area *systems* [emphasis added] (SCBD, 2010). This may be interpreted in two ways: that 'systems', by definition, are themselves well-connected; or, that 'systems' are to be well connected in order to form 'networks'. Based on the distinction provided by Agardy and Wolfe (2003), the idea that 'systems' must be well connected in order to form networks appears the most accurate of the two possible interpretations of Aichi target 11. While it is true that, by definition, a well-connected MPA 'system' would likely equate to the same level of protection as a MPA 'network', the interchangeable use of these terms remains important as it may be a contributing factor to the failure amongst experts to recognize the distinction between the two terms. Such a failure was demonstrated by the common tendency amongst the majority of experts to revert back to discussing the effectiveness of individual MPAs in conserving migratory pelagics despite being asked about the effectiveness of MPA networks. In this sense, experts appeared to be conceptualizing MPA networks as systems of MPAs comprised of individual areas that lacked connectivity between them. Importantly, it was this conceptualization that led many to question the conservation benefit of MPA networks for migratory species.

Thus, conclusions about the effectiveness of MPA networks for migratory species must acknowledge the requirement of connectivity between protected areas within the network. To this end, it is essential that international definitions, such as those proposed by the IUCN, make this distinction clear. This is especially prudent in light of its critical implications for migratory species conservation in particular; conclusions about the potential effectiveness of MPA networks for the conservation of migratory species must be made in the context of a network approach that ensures connectivity between MPAs, and not merely a system of MPAs as defined by Agardy and Wolfe (2003). Marine conservation in general will benefit from a refined IUCN definition that explicitly distinguishes between MPA systems and MPA networks, as it will lead to improvements in clarity of communication in general, as well as more accurate assessments of effectiveness for migratory species in particular.

3.4.2 Dynamic MPAs & long-term protection

The IUCN definition of a protected area requires that protected areas "…be managed in perpetuity and not as short term or a temporary management strategy" (Day et al., 2012). This is significant, given that long-term protection and clearly defined boundaries are two common characteristics that emerge of MPAs that carry strong conservation benefits (Edgar et al., 2014; Sala and Giakoumi, 2017). However, the conceptualization of 'long-term' protection within expert provided definitions of MPA demonstrates a departure from that provided within the IUCN definition. Indeed, while the IUCN defines long-term as *in situ* protection that is ongoing and without end (i.e. in perpetuity), several experts highlighted the need for 'long-term' protection through the establishment of dynamic MPAs within MPA networks that can be enforced seasonally or can change coordinates to follow species movements. In a sense, the experts' conceptualization of long-term may represents a shift in focus to the protection of species' 'functional' requirements, rather than protection of 'structural' habitat components. According to IUCN guidance (Day et al., 2012), however, such seasonal or temporary closure of an area for a specific purpose (such as whale breeding) should not be considered an MPA unless it is complemented by additional biodiversity protection and a primary nature conservation objective. Another concern with dynamic MPAs is that they introduce the potential for critical habitat areas to be damaged or degraded between periods of temporary protection (Lemieux et al., 2019). If this degradation is severe enough, these areas may no longer be suitable as critical habitat, and would thus not provide either periodic or long-term protection (Day et al., 2012). Therefore, the dynamic MPAs advocated for by some experts in this study, in which MPA coordinates would be changed in response to tracked movements of migratory species, would likely not be considered MPAs by other experts or by the IUCN. Although experts' arguments in favour of dynamic MPAs are based on protection of a particular 'function' (i.e. breeding or foraging) as its location changes over time and space, they fail to give equal consideration to the importance of providing long-term protection of the place and associated broader ecosystem-wide objectives of stability and adaptability. The ability to integrate dynamic approaches into the design of effective MPA networks in a way that will not compromise long-term protection remains a challenge and is an area of active research (Hyrenbach et al., 2000; Norse et al., 2005; UNEP, 2007; Game et al., 2009; Hobday, 2011; Notarbartolo Di Sciara et al., 2016).

3.4.3 Other effective area-based conservation measures (OEABCMs)

Several experts suggested that the concept of OEABCMs mentioned in Aichi Target 11 may offer the flexibility needed to incorporate dynamic areas into MPA networks for migratory pelagics. OEABCMs give nations the ability to count areas other than formally recognized protected areas towards the target. Current draft guidelines by the IUCN-WCPA define an OEABCM as a "geographically defined space, not recognized as a protected area, which is governed and managed over the long-term in ways that deliver the effective and enduring in-situ conservation of biodiversity, with associated ecosystem services and cultural and spiritual values" (IUCN, 2018). This definition shares many similarities to the IUCN definition of an MPA, unsurprising given that OEABCMs must be consistent with the overall intent of MPAs (Lemieux et al., 2019). The distinguishing criterion is that MPAs require a primary conservation 'objective', while OEABCMs do not; however, they must still 'deliver' the effective in-situ conservation of biodiversity, regardless of objective (Mackinnon et al., 2015; IUCN WCPA, Draft, 2019). While only formally recognized protected areas (PAs) and OEABCMs may be counted towards Target 11, it must be recognized that all spatial conservation tools may have the potential to contribute to an MPA network even if lacking the reporting requirements of Target 11. These other area-based conservation approaches can be reported against other targets, such as Aichi Target 6 (sustainable fisheries) (IUCN-WCPA, Draft, 2019).

Since they must meet all requirements of an IUCN protected area, OEABCMs must provide protection and management over the long-term. Therefore, short term management strategies such as temporary closures cannot qualify as OEABCMs. However, IUCN OEABCM guidelines state that sites that are managed seasonally, such as to protect a migratory species during a particular life history stage, may qualify as OEABCMs, as long as the seasonal measures are a part of a long-term management regime (IUCN-WCPA, 2018) providing long-term benefits to the overall ecosystem (Lemieux et al., 2019). Thus, unlike the IUCN definition of MPA, which does not allow temporal flexibility, OEABCMs appear to have the potential to contribute to the dynamic and flexible management that experts argue is required within effective MPA networks for mobile pelagics. However, since they must be embedded within the overall management of the ecosystem, and 'deliver the effective and enduring in-situ conservation of biodiversity', they will likely only be dynamic in time (i.e. seasonal closures during nesting or foraging), rather than space (i.e. spatial protection that closely follows a species). The latter type of dynamically managed areas may well be important to conservation of these species, but they would not be considered as MPAs or counted as OEABCMs under Aichi Target 11.

3.4.4 IUCN PA definition & management categories – Implications for Aichi Target 11

As part of international obligations under the CBD and Aichi Target 11, most nations are working towards establishing comprehensive, adequate, representative, and well-connected networks of MPAs. Assigning internationally recognized IUCN protected area categories to these MPAs is a crucial part of this process (Fitzsimons, 2011). While not binding, the IUCN has recommended that "national governments acknowledge the IUCN definition of a PA, including the full range of PA management categories and governance types, as a primary basis for the inclusion of protected areas to contribute towards meeting Target 11" (IUCN, 2012). The IUCN defines six categories of protected area management (Dudley, 2008), and has released specific guidance on their application to MPAs (Day et al., 2012). However, despite this attempt to redefine protected area categories and their application to MPAs, there is a persisting lack of clarity surrounding, and inconsistent application of, the definition of MPA (Dudley et al., 2008; Day et al., 2012).

The IUCN provides the definition of MPA most commonly used by marine managers internationally (Day et al., 2012). However, this definition has been modified in discussions, policies, and organizational documents, and many nations have developed their own working definitions. For example, Fisheries and Oceans Canada defines a MPA as a "…part of the ocean that is legally protected and managed to achieve the long-term conservation of nature" (DFO, 2017), and the National Oceanic and Atmospheric Administration defines it as, "Any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein" (NOAA, 2017).

The IUCN uses the term "MPA" as a general umbrella term to cover all marine areas that meet the IUCN protected area definition, regardless of differences in purpose, design, management approach, or designated name, such as marine park, marine reserve, fisheries reserve, biosphere reserve, sanctuary, marine and coastal protected area, large marine protected area, ‘no-take area’, national marine conservation area, marine wilderness area, national marine park, or nature reserve (UNEP-WCMC, 2008; Day et al., 2012; see, for example Reeves, 2000; Agardy et al., 2003; Hooker and Gerber, 2004; Hoyt, 2009; Hays et al., 2014; White et al., 2017). However, the definition attributed to each of these types of spatial strategies, and the types of activities permitted within their boundaries, can vary across local, national, and international contexts. This is particularly true for ‘park’, ‘sanctuary’, and ‘reserve’: for example, in Kenya, National Marine Parks prohibit fishing or extraction of any kind, and marine reserves allow for non-destructive forms of fishing, while in Tanzania, marine parks are zoned for a wide range of uses, which can include fishing, and reserves are no-take areas (i.e. closed to all forms of extraction) (UNEP-WCMC, 2008).

While largely benign in the daily management effectiveness of a site, differences in understanding of what is meant by the term ‘MPA’ can be problematic when measuring progress towards global conservation targets. Further, differences in application and definitions across regional, national, and international contexts has led to a significant polarization of views regarding the potential effectiveness of MPA management approaches (Fitzsimons, 2011). Indeed, differences in understanding, interpretations, and application of the term ‘MPA’ was acknowledged by several experts in this study as an obstacle to the establishment of MPAs and MPA networks for migratory pelagics. Thus, such differences are not benign, and if unaddressed, may lead to the rejection of MPAs as an effective conservation strategy and a derailment of marine conservation efforts overall (Agardy et al., 2003).

According to UNEP-WCMC (2008), the IUCN categories attempt to provide an international standard for MPA designation and are a means of promoting an international "common language" (p. 18). Accordingly, IUCN guidelines state that the categories should be applied based on the primary management objective of the site, irrespective of the particular names given to the area (i.e. marine reserve sanctuary, marine park, biosphere reserve) (Day et al., 2012). Despite this guidance however, application of the IUCN categories has often been inaccurate and inconsistent (Day et al., 2012). For example, Canada allows some form of fishing in 160 of its 161 marine protected areas that are designated as IUCN categories Ia, Ib, and II, contradicting the intended objectives implied by their IUCN categories (Robb, 2011; Fitzsimons, 2011; Briggs et al., 2018), and Australia has allocated IUCN category II labels to zones allowing recreational fishing. Both examples represent a misapplication of an IUCN category meant to represent and confer high levels of protection (Fitzsimons, 2011). While the complex zoning schemes present in the majority of MPAs, ranging from single to multiple-zoning and from no-take to multiple-use areas, make it more difficult to assign many MPAs to specific IUCN categories (Horta e Costa et al. 2016), this is not likely the main cause of inaccurate application. Rather, the problem may stem from lingering uncertainty surrounding the term MPA and the opportunity it opens for nations to assign IUCN PA management categories representing high levels of protection to areas that do not meet the objective requirements, and further to label areas as 'MPAs' despite their failure to meet fundamental characteristics of the IUCN protected area definition (Fitzsimons, 2011; Agardy et al., 2016). When areas that do not meet the IUCN definition are nonetheless labelled a MPA, the term becomes meaningless and creates an illusion of greater protection (Fitzsimons, 2011; de Santo, 2013; IUCN-WCPA, 2018). The global situation is one featuring a "bewildering array" (Dudley, 2008) of areas possessing some sort of conservation objective, and inconsistencies with regard to appropriate use and designation of IUCN categories and definitions has made it difficult to assess how much of the oceans are covered by areas that are truly protected (Fitzsimons, 2011). Thus, the current push under the CBD to reach national and international targets for the protection of biodiversity demands that designation of protected areas be done in a consistent and credible manner.

Observation of these issues has led some researchers to propose a novel global classification system for MPAs based on regulation of uses as an alternative to the IUCN system (Horta e Costa et al., 2016). However, echoing Dudley et al. (2017), we believe that there are strong arguments in favor of sticking with the existing IUCN classification. Agardy et al. (2016) argued that uncertainty surrounding the definition of the term MPA persists even despite the IUCN's work to redefine protected area categories, including MPAs (Day et al., 2012), and that conservationists need to agree on a common language that captures the objectives of each type of MPA. However, the IUCN PA categories have already been revised to provide this common language (UNEP-WCMC, 2008; Day et al., 2012); thus, in addition to enhanced clarity in definitions, what is needed is stricter adoption of IUCN definitions, categories, and standards by the global marine conservation community.

3.4.5 Challenges to collaboration & implications for ABNJ

The current "UN Prep Com-Process," focusing on biodiversity beyond national jurisdictions (BBNJ), is regarded as one of the most promising advances in global MPA establishment (Gjerde and Rulska-Domino, 2012; De Santo, 2018; Harden-Davies, 2018;

Tiller et al., 2019; De Santo et al., 2019). If successful, it will provide a legal framework for conservation agreements in areas beyond national jurisdiction, a feat which is not possible with the current sectoral management. Accordingly, the need to foster international collaboration and management is critical, and unacknowledged differences between experts in their assumed definitions and applications of the term 'MPA' as well as the IUCN categories threatens to impede this necessary collaboration. Indeed, differences in the components captured within expert definitions of MPA within this study suggest that collaboration may be challenging even regionally or locally, let alone across international borders. Thus, it is essential that experts involved in scientific research be precise and consistent in their use of the terms MPA, MPA network and others to ensure that they are able to communicate effectively within and across sectors. For more effective communications and partnerships in marine conservation, greater clarity and consistency around the use 'MPA' is warranted; if experts possess divergent understandings of this key term, the collaborative efforts needed to reach such international agreements may be undermined (Beazley et al., 2010; Hall et al., 1997).

3.5 CONCLUSIONS & RECOMMENDATIONS

This study analyzed the expert judgements of marine conservation scientists, planners and policy makers on the potential effectiveness of MPA networks for conserving migratory pelagics. The results indicated that, while experts generally agreed that MPA networks will form a key element of the overall framework needed to provide effective conservation for highly migratory species, several challenges remain to be addressed: (1) discrepancies surrounding the definitions of 'MPAs' and OEABCMs; (2) lack of distinction between MPA 'networks' and MPA 'systems'; and, (3) uncertainty regarding the ability of MPA networks to provide for or accommodate the dynamic management deemed necessary for these species.

More than 15 years ago, Agardy et al. (2003) called for clarity in the definition of "marine protected area" in response to the existence of diverse and paradoxical professional views in the marine conservation community, and the same need persists today (UNEP-WCMC, 2008; MacKinnon et al., 2015; Agardy et al., 2016). The lack of a consistent language, typology and conceptual framing in reference to MPAs, MPA systems, and MPA networks continues to have significant implications for management, as divergent meanings in such core concepts not only impede the establishment of MPAs and MPA networks for migratory pelagics, but also pose challenges to the scale of collaboration that will be required to establish MPAs in ABNJ. Addressing these challenges is especially prudent given the current push to reach the goals set by Aichi Target 11. Further, clarity and consistency in definitions will be required for accurate assessments of the effectiveness of MPA networks. Thus, a refined IUCN definition of MPA network that distinguishes between MPA 'systems' and 'networks' on the basis of connectivity is prudent. The term MPA should apply solely to those areas that meet the IUCN definition of 'protected area' and other concepts, such as OEABCMs or dynamic management areas, should be used for those areas that do not meet the definition, recognizing that they also may provide conservation benefits.

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CHAPTER FOUR: CONCLUSION

This chapter integrates the findings and conclusions of chapters two and three, and highlights directions for future research. Specifically, this chapter will: (1) provide a summary of the main findings generated from this research project; (2) discuss the implications of such findings on the effectiveness of MPA networks for the conservation of migratory pelagics; (3) indicate limitations in interpreting the results; and (4) point to potential future research opportunities and next steps in marine policy and management practice.

4.1 SUMMARY OF RESEARCH – BACKGROUND AND OBJECTIVES

The populations of several migratory pelagic species are facing wide-scale population declines in response to various direct and indirect threats, including habitat loss, ocean changes associated with global climate change (warming, acidification etc.), and impacts associated with the extraction of natural resources (Lascelles et al., 2014; Schipper et al., 2008). In response, research has sought to assess the effectiveness of various conservation strategies for the conservation of such species, which includes the use of marine protected areas (MPAs).

While the benefits of MPAs for sessile species, habitats, and ecosystems have been widely documented (Friedlander et al., 2017; Tewfik et al., 2017), there is still considerable debate surrounding their utility for highly migratory pelagics. Indeed, given their wide distributions and extensive annual migrations, the argument that many of these species roam too far to benefit from stationary protected areas has been well established (Boerder et al., 2018; Game et al. 2009; Davies et al. 2012; Hooker and Gerber 2004). Research has ultimately concluded that isolated MPAs will not be able to effectively protect migratory pelagics from threats across their entire range, given their failure to ensure population connectivity. As a result, research has shifted away from focusing on individual MPAs to assessing the conservation value of MPA networks, proposing that well-designed networks of MPAs have the potential to contribute to the conservation of migratory species through the protection of critical habitats (DFO, 2016; White et al., 2017; O'Leary et al., 2018) and by reducing species' cumulative exposures to threats (Hinch and De Santo, 2011; Hooker et al., 2011; Hooker and Gerber, 2004).

However, MPA managers, planners, and scholars possess diverse opinions and perspectives surrounding the capacity of MPA networks for the conservation of migratory pelagics. As a result, the question of whether or not MPA networks, if designed for these species, could be potentially effective, remains open and disputed in the literature and in practice. This thesis sought to help inform and contribute to this debate by synthesizing the current state of knowledge on the effectiveness of MPA networks for migratory pelagics, as depicted within the scientific literature and as conveyed through expert interviews. To this end, the study was guided by three research objectives:

1. To assess whether five IUCN ecological and biophysical guidelines for MPA network design were addressed within the current scientific literature; and, inversely, whether the themes emphasized within the literature around the effectiveness of MPA networks for migratory species were reflected within the IUCN guidelines;

2. To determine the nature, basis and range of expert judgements on the potential effectiveness of MPA networks for migratory pelagics; and,
3. To determine the most pressing challenges and opportunities associated with fostering a common understanding and collaborative approach to designing and establishing effective MPA networks for conserving migratory species.

4.2 SYNTHESIZING RESULTS FROM PUBLISHED LITERATURE & EXPERT JUDGEMENTS: WHAT HAVE WE LEARNED?

There was a high degree of overlap between the findings from the literature review and expert interviews. Accordingly, this research distilled four overall findings, the details and implications of which are discussed below:

1. MPA networks have the potential to provide effective conservation for highly migratory pelagics; however,
2. Effective MPA networks must be designed to provide ecological linkages between all critical habitat areas through connectivity and must possess management plans that incorporate adaptive strategies and call for international collaboration;
3. The lack of distinction made between, and the interchangeable use of, MPA 'network' and MPA 'system' in internationally utilized definitions and gatherings endorsing the global need for MPA networks contribute to ambiguous and inconsistent applications of both terms, which in turn influence judgements about the effectiveness of MPA networks for migratory pelagics and create challenges for successful collaboration;
4. While arguably important components, uncertainty exists around how to incorporate dynamic approaches into MPA networks for migratory pelagics as

they cannot be considered 'protected areas', per se, if they do not confer long term protection, as defined by the IUCN.

4.2.1 Implications for the effectiveness of MPA networks for migratory pelagics

Through an analysis of scientific literature and expert judgements, this thesis illustrated the current state of knowledge surrounding the effectiveness of MPA networks for the conservation of migratory pelagics. Given that the experts chosen for participation are at the center of marine conservation planning, policy, and research, it was not surprising to find a high degree of coherence between their judgements and the themes emphasized in the literature. Overall, evidence from both sources supported the potential effectiveness of MPA networks for migratory pelagics, emphasized the need for networks to provide ecological linkages through connectivity, and advocated for management plans that incorporate adaptive strategies and call for international collaboration. However, this research also found that published literature and expert responses suffered from the same inconsistent application and definition of core concepts, which subsequently impacted their ability to draw accurate conclusions about the potential effectiveness of MPA network for this suite of species. Indeed, findings from both the review and interview analyses highlighted the importance of clarity and consistency in definitions and demonstrated how semantic confusion and inaccurate application of labels and concepts can impede common understanding, and thus collaboration, and ultimately hinder global conservation progress.

'Connectivity', a primary strategy of the IUCN ecological guidelines, was referenced in over two-thirds of reviewed studies (e.g., Worboys et al., 2016; Pendoley et al., 2014; Hinch and De Santo, 2011) and was identified as a key component of MPA networks by over half of the interviewed experts (n=10). Indeed, evidence from both analyses supported the argument that in order for MPA networks to be effective for migratory pelagics they must ensure the protection of connectivity across the species' full distributions and between all critical habitats (Pendoley et al., 2014; Geijer and Jones, 2015; Notarbartolo Di Sciara et al., 2016; O'leary et al., 2018). However, the attention allocated to the protection of migratory routes as critical habitat lagged significantly behind that of other critical habitat areas, particularly those used for foraging and breeding; the protection of migratory routes as critical habitat was discussed in less than half (42%) of reviewed studies, and by less than half of interviewed experts.

The simultaneous emphasis on connectivity on the one hand and lack of attention to migratory routes as critical habitat on the other is an important contradiction; MPA networks that do not protect migratory routes will fail to provide connectivity at the necessary scale for migratory pelagics. This represents a significant gap in research attention, and a major roadblock to effective MPA network design and implementation for pelagic conservation. Thus, closing and addressing this gap or challenge is critical. Until adequate consideration is given to protecting all critical habitat areas, including migratory pathways, MPA networks are likely to prove ineffective for maintaining or recovering populations of migratory pelagics.

The diminished attention allocated to migratory pathways may be a result of confusion surrounding what connectivity entails in the context of an MPA network for migratory pelagics. Such confusion can be attributed to the lack of distinction made between an MPA 'system' and MPA 'network' in internationally utilized definitions, such as that provided by the IUCN. While the IUCN defines a network as a group of MPAs that "…operates cooperatively and synergistically…" (IUCN-WCPA, 2008, p 111), it does not explicitly identify the need for connectivity, nor does it distinguish the difference between systems and networks. This is important given that while connectivity is an integral component of a true MPA network, systems of MPAs are not necessarily designed to provide connectivity. Thus, there is a need for greater clarity in the definition of MPA network, with a particular focus on distinguishing between 'systems' and 'networks' of MPAs; the label of a 'network' must be exclusively applied when connectivity is an integral design component. The development of a refined definition of a MPA network that distinguishes it from an MPA system will help ensure that the two terms are not used interchangeably and that conclusions about the potential effectiveness of MPA networks for migratory species are made based on a commonly agreed or understood assumption of connectivity. In this sense, MPA networks for migratory pelagics, by definition, would include migratory pathways in their design and protective measures. Thus, improved clarity in definitions may help address the lack of attention directed at, and the knowledge gap surrounding, the protection of migratory corridors.

The failure to protect migratory pathways is likely also a symptom of the larger challenge of effective international management. Numerous pelagic species have annual migrations that carry them into the waters of several nations, and accordingly, the need to foster international collaboration and management is critical to their conservation. Indeed, both studies revealed the need for enhanced international efforts in the establishment of MPA networks for migratory pelagics. However, both also stressed the challenge this poses given the current sector-by-sector management structure in ABNJ. While the UNCLOS BBNJ instrument was referenced in the literature and mentioned by several experts as a promising solution, it is in the very early stages, and its success depends on efforts to improve cross border collaboration.

For more effective collaboration in marine conservation, greater clarity and consistency around the use of key terms is warranted, recognizing that divergent meanings in and use of core concepts have been found to impede and undermine collaborative efforts (Hall et al., 1997; Lindenmeyer and Fischer, 2006; Beazley et al., 2010). Thus, the term MPA should apply solely to those areas that meet the IUCN definition of 'protected area'. The IUCN PA definition attempts to provide a common term to encompass the variety of different types and labels of spatial management areas utilized globally. In a sense, this is an attempt to provide a "common language" (UNEP-WCMC, 2008) to serve as a basis for cross border collaboration. However, the benefits of this common language can only be seen if nations apply the label of 'protected area' accurately (i.e. to areas meeting the IUCN definition requirements); when marine areas that fall short of the PA definition are nonetheless labelled MPAs, it creates confusion and weakens global conservation progress.

Results from both the literature review and expert interviews indicated that adaptive management, and particularly 'dynamic MPAs', will be essential components of any MPA network that effectively conserves migratory pelagics. However, dynamic approaches cannot be considered 'protected areas', per se, if they do not confer long term protection as defined by the IUCN. Thus, the proliferation of calls for 'dynamic MPAs' within the scientific literature as well as among expert responses demonstrates the confusion and misapplication that exists surrounding the IUCN definition. In order to avoid further terminological confusion, it may be advisable to refrain from referring to such dynamic areas as MPAs, opting instead for dynamic marine areas, dynamic marine conservation areas, or some other such term. This should help clarify important distinctions between the terms, and in particular, help defuse disagreements that arise from concerns around the lack of long-term protection associated with such dynamic areas.

The challenge of vague and inconsistent definitions in marine conservation is not new. In a paper exploring the unresolved issues and ideological clashes around the use of marine protected areas, Agardy et al. (2003) argued that the broad applicability of the MPA label was contributing to a significant polarization of views regarding marine management approaches, a fact which the authors argued could potentially impede the use of MPAs for biodiversity conservation. These findings prompted the authors to call for clarity of definition. In a follow up study, Agardy et al. (2016) referred to this challenge as "definition slippage" (p. 12), and argued that lingering confusion and uncertainty over what constitutes a MPA can negatively impact the effectiveness of measures taken to protect marine biodiversity.

While we found no study or expert who fully debated the definition of MPA, MPA network, or MPA system, several did allude to the inconsistencies and confusion surrounding such definitions and the challenges they pose. In light of the current push to reach the goals Aichi Target 11, and especially with its introduction of OEABCMs, it is now even more crucial to ensure consistent use of definitions in marine conservation. Additionally, with the UN initiative for conserving biodiversity in ABNJ on the horizon, addressing the challenge of consistent meaning and use of core concepts among IUCN guidance and other experts involved in marine conservation planning is essential.

4.3 STUDY LIMITATIONS & DIRECTIONS FOR FUTURE RESEARCH

The results and limitations of our research raise a number of issues and questions that may warrant further study. Our expert interview study focused solely on local-regional experts; all participants possessed extensive knowledge of marine pelagics native to the North Atlantic and/or experience with MPA design and/or marine conservation planning. Given this delimited scope, it was possible that the results would not represent the opinions and judgements of marine experts globally. However, the consistency between expert judgements and the results from our broad scale literature review suggests that the findings are likely relevant beyond our limited interview scope. A further limitation was the failure to include stakeholders representing industry and rightsholders representing First Nations or Indigenous perspectives, due to lack of response and ethical considerations respectively. These two groups play important roles in marine conservation globally and possess unique knowledge sets. Thus, the inclusion of their perspectives would have added significant depth to our findings. The literature review did not provide sufficient information to close this knowledge gap, particularly in relation to Indigenous perspectives. This was not surprising, as Indigenous knowledge and methodologies are often not well represented or taken up by Western scientific thought. However, in order to achieve successful collaboration at a global scale, the viewpoints of all sectors, stakeholders and Indigenous Rights holders must be equally involved and valued. Thus, there is a clear need to increase the inclusion and coverage of Indigenous perspectives in marine conservation research generally, but especially in relation to the effectiveness of MPAs for migratory pelagics.

Previous studies have acknowledged the semantic confusion that exists surrounding several core concepts in marine conservation (Agardy et al. 2003; Agardy et al. 2016), and in an attempt to help aid in comprehension and accuracy, the IUCN produced specific guidelines for applying its PA categories to MPAs. Yet, despite this attention, the lack of clarity and confusion with respect to MPAs persists. This begs for further consideration of the factors contributing to the confusion and misapplication of such concepts. In particular, research would benefit from assessing whether the inconsistent application of IUCN definitions and categories is truly a result of confusion regarding definitions, or whether it is the result of a conscious choice. Relatedly, there is a need to assess whether the global push to reach global conservation targets, such as Aichi Target 11, is contributing to this misapplication; some (e.g., MacKinnon et al., 2015; Spalding et al., 2016; Lemieux et al.2019; Zurba et al., 2019) have argued that the focus on reaching particular quantitative targets for protection takes away from a focus on the quality of such protection.

Despite such methodological limitations and unanswered questions, this work nevertheless contributes to an important gap in knowledge. Not only do the findings from the literature review and the expert interviews elucidate the current factors influencing judgements surrounding the potential effectiveness of MPA networks for the conservation of migratory pelagics, but they also help to further the discussion surrounding the semantic confusion within marine conservation and identify the need for revisions to certain IUCN definitions. Further, our findings identify the potential barriers and opportunities to the establishment of MPA networks, and potentially to the conservation of large, at-risk, migratory pelagic species. Addressing questions of MPA network effectiveness is especially prudent in light of current efforts to meet international commitments for MPA designation, particularly those under Aichi Target 11, as well as the current focus by the

United Nations on protecting biodiversity in ABNJ. Despite the limitations, this study shows that, when one looks below the surface of the inconsistent use of the terminology to reveal the deep understandings and rationale around the effectiveness of MPA networks for these species, there is almost unanimous agreement that MPA networks, if well designed, should be effective for migratory pelagics, and indeed, are likely imperative to their persistence. As such, the research performed in this thesis should be of interest to marine conservation scholars, advocates, and managers alike.

4.4 CONCLUDING COMMENTS

This research has gathered information through a broad literature review and expert interviews in order to provide a summary of the current debate and state of knowledge surrounding the potential effectiveness of MPA networks for conserving migratory pelagics. This included identifying the factors influencing judgements of effectiveness, as well as the current barriers and opportunities for establishing MPA networks for migratory pelagics. While our research showed that networks of MPAs are widely agreed to be potentially effective for migratory pelagics if well designed, established, and managed, it also highlighted a clear need for an increased focus on the planning, design, establishment, and management of MPA networks for this suite of species. Specifically, issues that arose as warranting attention included the protection of migratory routes, the challenges associated with the inclusion of adaptive and dynamic planning frameworks within MPA networks, and the factors hindering successful international collaboration. As efforts to establish networks of MPAs continue to progress globally, and as work continues on the UN BBNJ instrument, it is essential that such factors are thoroughly addressed. To support such efforts, updates to the 2008 IUCN ecological guidelines are needed that incorporate a revised definition of MPA ‘network’ to explicitly include ‘connectivity’, and updates to broader IUCN guidance around MPA network governance and management considerations are warranted, particularly around adaptive and dynamic planning frameworks and international collaboration.

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APPENDIX A – LITERATURE REVIEW GUIDE

Table A1**.** Keywords used in article search for literature review.

Key Search Terms
Marine protected area OR marine reserve OR marine protected area network **AND** Migratory OR transboundary OR pelagic **AND** "at-risk" OR endangered OR threatened

Table A2. Definition of codes used for literature summary documents.

Source Code	**Source Type**
JP	Published journal article
R	Organizational/government report
D	PhD Dissertation

APPENDIX B – ARTICLE INFORMATION FOR DOCUMENTS INCLUDED IN LITERATURE REVIEW. # = SOURCE NUMBER. FULL CITATIONS CAN BE FOUND IN FOUND IN REFERENCES.

[JP=journal publication, R = organization/government report, D = PhD Dissertation]

#	Publication Year	Author(s)	Title	Source Type
1	2015	Harris, L. R., Nel, R., Oosthuizen, H., *et al.*	Paper-efficient multi-species conservation and management are not always field-effective: The status and future of western Indian ocean leatherbacks.	JP
2	2000	Reeves, R.	The value of sanctuaries, parks, and reserves (protected areas) as tools for conserving marine mammals.	JP
3	2000	Hyrenbach, K., Forney, K., & Dayton, P.	Marine protected areas and ocean basin management.	JP
4	2003	Augustowski, M., & Palazzo, J.	Building a marine protected areas network to protected endangered species: whale conservation as a tool for integrated management in south America	JP
5	2004	Hooker, S., & Gerber, L.	Marine reserves as a tool for ecosystem-based management: The potential importance of megafauna	JP
6	2005	Gerber, L., Hyrenbach, D., & Zacharias, M.	Do the Largest Protected Areas Conserve Whales or Whalers?	JP
7	2005	Norse, E. A., Crowder, L. B., Gjerde, K., *et al.*	Place-based ecosystem management in the open ocean.	JP
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9	2008	CMS Secretariat	Migratory Marine Species: Strategic considerations for 2009-11 and beyond.	R
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11	2009	Game, E. T., Grantham, H., Hobday, A., *et al.*	Pelagic protected areas: the missing dimension in ocean conservation	JP
12	2009	Hoyt, E.	Marine protected areas	JP
13	2009	Ashe, E., Noren, D., & Williams, R.	Animal behaviour and marine protected areas: Incorporating behavioural data into the selection of marine protected areas for an endangered killer whale population.	JP
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			protect and conserve the north atlantic right whale (eubalaena glacialis)	
15	2011	Hobday, A. J.	Sliding baselines and shuffling species: Implications of climate change for marine conservation.	JP
16	2011	Hooker, S., Canadas, A., Hyrenbach, D., *et al.*	Making protected area networks effective for marine top predators.	JP
17	2012	Silva, M. A., Prieto, R., Magalhães, S., *et al.*	Incorporating information on bottlenose dolphin distribution into marine protected area design	JP
18	2012	CMS Secretariat	The role of ecological networks for conserving cetacean habitat in the pacific islands region.	JP
19	2013	Goetze, J. S., & Fullwood, L. A. F.	Fiji's largest marine reserve benefits reef sharks.	JP
20	2013	Pulcini, M., Pace, D. S., La Manna, G., *et al.*	Distribution and abundance estimates of bottlenose dolphins (tursiops truncatus) around lampedusa island (Sicily channel, Italy): Implications for their management.	JP
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22	2013	Schofield, G., Scott, R., Dimadi, A., *et al.*	Evidence-based marine protected area planning for a highly mobile endangered marine vertebrate.	JP
23	2014	Ceccarelli, D. M., Frisch, A. J., Graham, N. A., *et al.*	Habitat partitioning and vulnerability of sharks in the great barrier reef marine park.	JP
24	2014	Lascelles, B., Di Sciara, G. N., Agardy, T., *et al.*	Migratory marine species: Their status, threats and conservation management needs.	JP
25	2014	Hays, G. C., Mortimer, J. A., Ierodiaconou, D., *et al.*	Use of long-distance migration patterns of an endangered species to inform conservation planning for the world's largest marine protected area.	JP
26	2014	Pendoley, K. L., Schofield, G., Whittock, P. A., *et al.*	Protected species use of a coastal marine migratory corridor connecting marine protected areas.	JP
27	2015	Pérez-Jorge, S., Pereira, T., Corne, C., *et al.*	Can static habitat protection encompass critical areas for highly mobile marine top predators? insights from coastal east Africa.	JP
28	2015	Geijer, C. K., & Jones, P. J.	A network approach to migratory whale conservation: Are MPAs the way forward or do all roads lead to the IMO?	JP
29	2016	Notarbartolo Di Sciara, G., Hoyt, E., Reeves, R., *et al.*	Place-based approaches to marine mammal conservation	JP

30	2016	Lindsay, R. E., Constantine, R., Robbins, J., *et al.*	Characterizing essential breeding habitat for whales informs the development of large-scale marine protected areas in the south pacific.	JP
31	2017	White, T. D., Carlisle, A. B., Kroodsma, D. A., *et al.*	Assessing the effectiveness of a large marine protected area for reef shark conservation.	JP
32	2017	Reynolds, S. D., Norman, B. M., Beger, M., *et al.*	Movement, distribution and marine reserve use by an endangered migratory giant	JP
33	2005	King, M., & Beazley, K.	Selecting focal species for marine protected area network planning in the Scotia–Fundy region of Atlantic Canada	JP
34	2007	United Nations Environment Programme (UNEP)	Guidelines for the Establishment and Management of Marine Protected Areas for Cetaceans	R
35	2011	International Council for the Exploration of the Sea (ICES)	Report of the Working Group on Marine Mammal Ecology	R
36	2005	Chapman, D., Pikitch, E. K., Babcock, E., *et al.*	Marine reserve design and evaluation using automated acoustic telemetry: a case-study involving coral reef-associated sharks in the Mesoamerican Caribbean	JP
37	2011	Grüss, A., Kaplan, D.M., Guénette, S., *et al.*	Consequences of adult and juvenile movement for marine protected areas	JP
38	2013	Toonen, R. J., Wilhelm, T. A., Maxwell, S. M., *et al.*	One size does not fit all: The emerging frontier in large-scale marine conservation	JP
39	2017	Roberts, C. M., O'leary, B. C., McCauley, D. J., *et al.*	Marine reserves can mitigate and promote adaptation to climate change	JP
40	2017	Davies, T.E., Maxwell, S.M., Kaschner, K., *et al.*	Large marine protected areas represent biodiversity now and under climate change.	JP
41	2018	O'Leary, B.C., Ban, N.C., Fernandez, M., *et al.*	Addressing Criticisms of Large-Scale Marine Protected Areas.	JP
42	2011	Maxwell, S.M., Breed, G.A., Nickel, B.A., *et al.*	Using satellite tracking to optimize protection of long-lived marine species: Olive ridley sea turtle conservation in Central Africa	JP
43	2012	Scott, R., Hodgson, D.J., Witt, M.J., *et al.*	Global analysis of satellite tracking data shows that adult green turtles are significantly aggregated in Marine Protected Areas.	JP
44	2004	Palumbi, S.R.	Marine reserves and ocean neighborhoods: The Spatial Scale of Marine Populations and Their Management	JP

45	2009	Jorgensen, S. J., Reeb, C. A., Chapple, T. K., *et al.*	Philopatry and migration of Pacific white sharks	JP
46	2014	Vandeperre, F., Aires-da-Silva, A., Fontes, J., *et al.*	Movements of blue sharks (Prionace glauca) across their life history.	JP
47	2017	Ward-Paige, C. A., & Worm, B.	Global evaluation of shark sanctuaries	JP
48	2012	Davidson, L. N. K.	Shark Sanctuaries: Substance or Spin?	JP
49	2013	Hazen, E. L., Jorgensen, S., Rykaczewski, R. R., *et al.*	Predicted habitat shifts of Pacific top predators in a changing climate	JP
50	2012	Davies, T. K., Martin, S., Mees, C., *et al.*	A review of the conservation benefits of marine protected areas for pelagic species associated with fisheries	JP
51	2010	Kaplan, D., Chassot, E., Gruss, A., *et al.*	Pelagic MPAs: The devil is in the details	JP
52	2016	Graham, F., Rynne, P., Estevanez, M., *et al.*	Use of marine protected areas and exclusive economic zones in the subtropical western North Atlantic Ocean by large highly mobile sharks	JP
53	2018	Boerder, K.	Tracking global fisheries from space: patterns, problems, and protected areas	D
54	2014	Edgar, G.J., Stuart-Smith, R. D., Willis, T. J., *et al.*	Global conservation outcomes depend on marine protected areas with five key features	JP
55	2011	Block, B. A., Jorgensen, S., Jonsen, I. D., *et al.*	Tracking Apex Predators in a Pelagic Ocean	JP
56	2015	Chapman, D. D., Feldheim, K. A., Papastamatiou, Y. P., *et al.*	There and Back Again: A Review of Residency and Return Migrations in Sharks, with Implications for Population Structure and Management.	JP
57	2016	Worboys, G. L., Ament, R., Day, J. C., *et al.*	Connectivity Conservation Area Guidelines IUCN	R

APPENDIX C – SUMMARY OF ECOLOGICAL GUIDING PRINCIPLES TO HELP BUILD RESILIENT MPA NETWORKS (IUCN-WCPA, 2008, TABLE 9, P. 62)

Ecological Guideline	Strategies
1. Include the full range of biodiversity present in the biogeographic region	Representation: Represent a minimum of each habitat type and physical environment type in the overall MPA network.
	Replication: Have sufficient replication to safeguard against catastrophic events or disturbances.
	Representation of resilient and resistant characteristics: Chose sites that are more likely to be resistant or resilient to global environmental change.
2. Ensure significant areas are incorporated	Protection of unique or vulnerable habitats: Design MPAs to include biophysically special and unique places.
	Protection of foraging or breeding grounds: Design MPAs to include important areas for breeding feeding or socializing areas (rookeries, haul-outs, nesting, etc.).
	Protection of source populations: Design the MPA to include important sources of reproduction (nurseries, spawning areas, egg sources, etc.). MPAs located at source populations, when identifiable, can help retain recruits and larvae to sustain local populations, as well as serve to export surplus larvae.
3. Maintain long-term protection	Consider spillover: Spillover of adult and juvenile fishes and invertebrates can contribute to populations in fished waters outside MPAs, but may not be evident for years after protection. Spillover has been documented in MPAs around the world, including Saint Lucia, Kenya, the United States, Australia and the Philippines.
	Adaptive management: Include adaptive strategies in the MPA design which allow for adjustments as science evolves and community dynamics change. Design the MPA boundaries to be flexible in space and time so that they can be expanded or contracted, have seasonal or other time limits, be moved to different levels of protection, and so to be made more responsive to changing conditions (ecologically, social, economically).
4. Ensure ecological linkages	Connectivity: Recognize the patterns of connectivity within and among ecosystems (e.g. ecological linkages among coral reefs, seagrasses and mangroves).
	Consider adult movement and larval dispersal: Larval dispersal and adult movement vary greatly with species; design size and spacing of MPA network to maximize benefits.
	Consider adult movement patterns: Adult movement patterns and distances vary greatly with species, which influence the design of the MPA and response of species after the MPA is created.
5. Ensure maximum contribution of individual MPAs to the network	Consider size: Design individual MPAs large enough to: (1) accommodate the large-scale movement of adults and (2) include enough habitat for viable species and ecosystem protection.
	Consider spacing: Design network of MPAs to: (1) accommodate the long-distance dispersal of larvae and (2) capture the biogeographic range of variation in habitats and species.
	Consider shape: Design the shape of individual MPAs to: (1) take into account edge habitat (for biodiversity conservation it is important to minimize edge habitat and maximize interior protected area; in contrast, for fisheries management continuous habitat inside and outside of the reserve will enhance spill over effects); (2) maintain the latitudinal and longitudinal gradient in habitats and communities; and (3) facilitate enforcement.

APPENDIX D – SCRIPT ILLUSTRATING THE PROCESS UNDERTAKEN WHEN INTERVIEWING PARTICIPANTS

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Inspiring Minds

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This interview guide is constructed to give a general idea of the progression of interviews conducted with participants. As interviews are semi structured, questions included here merely comprise a general checklist that is used to ensure that similar information and inquiries are provided to everyone. However, due to the nature of the interview population (academic researchers, government managers, ENGO employees), the questions addressed in each interview may vary.

Initial briefing/greeting
Hello! Thank you again for taking your time to participate in my study. I appreciate any and all of the information you can provide. This was all outlined in the informed consent form, but just to reiterate, the purpose of these interviews is to get a sense of expert opinion on the effectiveness of MPA networks for migratory pelagics in a context of climate change, and you have been selected because of your knowledge and expertise in this area. I have some guiding questions that I will be asking to ensure that similar information is covered by all participants, but please feel free to expand or elaborate upon anything you wish. The interview should last at least 30 minutes but may be closer to an hour.

To ensure accuracy of documentation and so that I don't need to be distracted by taking notes, would it be alright with you if I recorded this interview?

Questions – general progression of interview rather than explicit script to be followed

1. In your words, what is a marine protected area?
    a. How would you *describe or define* it?
2. In your words, what is a marine protected area *system*? How does this differ from a marine protected area *network?*
3. Do you think of MPAs as including coastal or freshwater aquatic areas?

    MPA Network Definition – for the purposes of my project, I am using the IUCN definition of an MPA network
    a. "a collection of individual marine protected areas that operates cooperatively and synergistically, at various spatial scales, and with a range of protection

levels, in order to fulfill ecological aims more effectively and comprehensively than individual sites could alone"

4. So, now moving on to the concept of connectivity, can you tell me connectivity means to you in a marine context?
5. In theory, what do you think MPA networks are *meant* to protect?
6. What do you think MPA networks are actually *able* to protect in practice?

7. Can you give me a brief description of the MPA network development and planning process?
8. What is th primary goal of Canada's MPA network?
    a. What are the main objectives for the Scotian shelf bioregion?
9. How big do you think MPAs should be?
10. How do you think the size of a MPA network should be determined?
11. What are the size, shape, and location criteria for MPA network design?

12. Given the IUCN definition of an MPA network, do you think MPA networks, if well designed and established, could protect species at risk? Large-bodied species? Pelagic species? Migratory species? Other wide-ranging species? Those that utilize both coastal and marine, and/or both marine and freshwater systems?
    a. Do you think MPA networks, if well designed and established, could protect species with many or all of these characteristics?
    b. How is DFO currently incorporating large pelagics into the design strategies of the MPA network?
        i. How are the needs of large pelagics being addressed?

13. Do you think that climate changes would impact the effectiveness of MPA networks? Why/why not? How?
14. Should climate change considerations be incorporated into MPA network planning? Why/why not? How so?
    a. In general?
    b. For particular species? Which ones?

15. Do you think that it is realistic to think that well-designed MPA networks for such species (highly migratory pelagics) could/should be established? Why/why not?
16. What are the impediments to MPA network establishment?
17. What are the opportunities for MPA network establishment?
18. Do you see these changing in the future?
19. Are different approaches needed in the inshore versus the off shore (within nation-state-controlled zones) versus the high (international) seas?
20. Would any new international or bilateral mechanisms need to be put in place? Such as?
    a. What would be involved in establishing MPAs on the high seas for such migratory species
    b. Probe for BBNJ instrument, current management approaches in ABNJ, and how countries can continue momentum in meantime.

21. Are there other methods you think would be more effective than MPA networks for these species?
    a. Do you think that such other measures would suffice on their own, without including MPA networks as part of the conservation or management strategy?
22. Do you think that dynamic ocean management would be (a) a more effective substitute or (b) a good complement to MPA networks? Why/why not? In general or particularly for migratory species?
23. Any further questions or comments that you would like to add?

Closing Remarks
Thank you again for your time today, it was really great to speak with you. Before I go, I wanted to ask if you had any suggestions of possible sources/ authors/ people I should contact for an interview?

Lastly, would I be able to contact you again if I have further questions?

Thank you!

APPENDIX E – SPECTRUM OF EXPERT SUPPORT [QUOTE EXCERPTS]

Level of Support	Expert #	Quote Excerpt
Strong	1	"Yes, I definitely see their [MPA networks] potential".
	13	"Yes, absolutely. I would say it's [MPA networks] one of the tools we need to protect highly migratory species".
	11	"…I think if you protect important areas for highly migratory species within a network then it fully fits with the concept/theory behind network design".
	15	"If it's designed for them, with them in mind, yeah I think so. I do think so.".
	2	"Yes". "I think any migratory species could actually benefit from being considered within a framework of a network of protected areas as long as you're thinking about it from a perspective of when and why they're interacting with particular stressors".
	8	"Yeah. I think it can be targeted at key feeding points, breeding points, vulnerable areas".
Limited	17	"I honestly think that for highly migratory or large pelagic species … fisheries management measures might actually be the best tool because they can be across their whole range. Sometimes spatial protection will be the right answer and sometimes it won't …".
	7	"I would think so … it depends on the distribution of the species".
	6	"Yeah I think so. Some but not all".
	14	"I would hope so. I mean I couldn't say anywhere off the top of my head that is, you know, that is achieving all of that yet".
	16	"Species that are cross boundary are certainly a little more difficult to protect. Species that have a range within a jurisdictional area that Canada's responsible for, the answer is yes".
	12	"I think MPAs have a role to play in helping to protect migratory species, but it depends on the life history of the species that you're talking about … for some … that are more wide ranging … it becomes harder".
	4	"I think there is potential for MPAs to protect them, I don't know if following the IUCN definition will do that".
	9	"I think so yeah… if the network is well placed…then they definitely have an impact".
	5	"It can only protect something that is going to spend some significant period of time as a resident in the area at some point in its lifecycle. The White shark… generally speaking when they come through its probably not going to be a marine protected area that's going to answer anything

		for those particular animals needs for protection just because they are so highly migratory”.
	3	“Yes and no. I mean I think it's a good step forward if you can fully implement the MPAs and what the IUCN is driving for…I guess my bottom line would be its probably not going to be good enough…”
No Support	8	“I don't think it’s feasible because of their range. I don't think its practical. I think that MPAs are amazing for … things that are static in their range… but I think for leatherbacks it would have to be the whole ocean”.

APPENDIX F – EXPERT DEFINITIONS [QUOTE EXCERPTS]

Term	Expert #	Quote Excerpt
Marine Protected Area	1	"It's an area that excludes certain forms of human use, typically the extractive uses".
	2	"… an area of the ocean that is managed more strictly that the surrounding area for the purpose of conserving biodiversity".
	3	"I would go back to the IUCN definition which I forget right off the top of my head exactly what it is, but the idea that it has to be long term legal protection, and it kind of excludes certain areas like fishery protection areas that are done annually or that kind of thing. So I guess I would go back to that as the most accepted definition. Beyond that I mean it's really up to each country to define it, and then the Convention on Biological Diversity they kind of come at it from another angle. And then even now with the whole areas beyond national jurisdiction process is just completed in the UN, they are probably going to move forward to a new convention hopefully, but even there you look at what they talk about as marine protected areas and other effective area based measures, and that was a 2020 target under the CBD as well, so obviously there's marine protected areas and then other effective area based measures, so it's that kind of grey line between where you go from an MPA to other area based measures. I guess I'd just say IUCN is a pretty good definition, but it's still contested".
	4	"So, a marine protected area is a defined area in the marine environment that is meant to limit activities that may harm the conservation objectives or the purposes for why the marine protected area was put in place in the first place".
	5	"It's a protected space where there are restrictions on activities. Those restrictions are variable form jurisdiction to jurisdiction, so some places will limit fishing, others will not, some places will permit boating and diving, others will not. So, there are different levels of what a marine protected area is, but at the end of the day, for protecting species that are at risk you probably need the more severe rather than the less severe restrictions".
	6	"…well it's a bit of the ocean, where human activities are significantly reduced".
	7	"We have a typical definition that we generally use and is generally accepted. A clearly defined geographical space that's recognized, dedicated, and managed through legal or other effective means to achieve long term conservation of nature with associated ecosystem functions and cultural values. I think that pretty much covers it".
	8	"It's an area of the sea that's been federally recognized through the federal government as important for a particular area or set of marine

		species, both plants and animals or one or the other”. “So, it doesn’t mean that no one can fish in a marine protected area, it just means that only certain types of activities are allowed in those areas”.
	9	“I tend to go off the IUCN definition of an area, some sort of spatial area, where certain restrictions apply, recognizing that this can be anything from a paper park to a no take zone and, yeah, its hugely tied to the objective you’re looking at if you’re coming from the conservation aspect or the fisheries aspect or other areas, but generally I would stick with that”.
	10	“It’s an area designated, if you’re talking about international spaces it’s designated under law, dedicated to the conservation of nature and associated ecosystem values. Long term conservation of nature. This is what we’re fighting over – it’s got to be the long-term conservation of nature if you’re going to start distinguishing from the sectoral organizations”.
	11	“… an area or part of the ocean that’s managed or set aside for the long-term conservation of nature. So, you know, key components to the definition are, it’s a spatial area, its set aside or managed so it implies that there’s restrictions on what we can do there, and long term right? But I would add one more thing that’s not really clear in that simple definition, is, and its relevant to your thesis, I think it needs to be year-round too to be a marine protected area in my mind as a practitioner”.
	12	“A marine protected area is a space in the ocean that’s managed for the conservation of species and habitats contained therein. It means that MPAs are legally defined, they have to have boundaries, they have to be long term, and they are meant to provide protection but it means that there can be various levels of protection ranging from places that are no go where people can’t even go to those that are no take where there is no extractive activities, all the way through to sustainable uses sort of IUCN category definitions 1-6”.
	13	“Okay, so I would say its a bit of the ocean that we are going to try and manage a bit better than the rest of it, which I know is very vague. The reason why I say its vague is because if we look at the IUCN definitions of what a marine protected area can be, you can go all the way from hard no entry zones where nobodies allowed in, you can go all the way through to these sustainable use zones where it can kind of almost be anything. Then of course you have different countries and how they apply the term marine protected area”.
	14	“Yeah, so for me an MPA is the IUCN definition of a marine protected area, so it implies a lot of weight to it, it’s not just lines on a map; there’s active management of the site, it’s the entire water column because that’s one thing, some people are like ‘“you know we protected the bottom”’ but you can still do everything else on the top and that’s not in the spirit of what it’s supposed to be”.

	15	"I would define a marine protected area, you know, capital M capital P capital A, is a government of Canada Oceans Act mechanism which I won't explain to you because Im sure you know. Marine protected area not capitalized MPA is simply an area that has a conservation objective associated with it, that is managed to ensure any activity that takes place in it contributes to that conservation objective or at least doesn't inhibit it, it tends to be long lasting and it tends to be defined in area".
	16	"A marine protected area is a geographically defined space within um... the ocean, whether it be a coastal area or an ocean area that, provides a safe haven for species of um... conservation focus. Um... and by safe haven I mean that the area is managed differently than the surrounding waters, so it would likely include restrictions for um... a number of human activities, and there's many different types of marine protected areas in legislation, there's also guidance that is developed by IUCN which defines MPAs um... so I think there's a fairly well understood definition of marine protected areas and you know by the scientific research that can easily define the term".
	17	"So, I think it's an area where there is some restriction of human activity, with the outcome being biodiversity conservation. I'm agnostic about it as a legal tool".
Marine Protected Area Network	1	"Well a network you have a variety of marine protected areas together that achieve a goal that cannot be achieved by any protected area by itself".
	2	"…a network would be a variety of areas that are designed together to operate as a whole to have some sort of extra function to add value to each individual MPA; to provide some sort of value that each individual MPA can't provide on its own. That's the difference between a network and a system as well. A system wouldn't necessarily be designed to add value above and beyond individual components of the system, but the network is meant to be designed to provide that".
	3	"…the idea would be that you try to look from an ecosystem approach or ecosystem based management approach and you look at all the different ecosystem relationships and your network probably has to be quite dynamic and flexible, including for migratory species because they obviously come and go and are here only certain times of the year, so it's very complicated".
	4	"So, the way I see a marine protected area network is just a combo or a collaboration of singular MPAs that are put together for potentially specific objectives or purposes, and so they cover a broader scale of the marine area as opposed to just using one single MPA over the entire place". "…they are established for a purpose or a goal or conservation objective, so you're not just creating a network out of single MPAs that have no real connectivity between them, but there's a reason why these MPAs are being considered in a network or in a whole together".

	5	"As I would envision networks, they're a series of interconnected reserves. The interconnections is the free flowing ocean that you have surrounding you, whether those pathways are blocked or not blocked is going to depend very much upon whether we are successful in managing future ocean development and the various installations that we are going to be putting in, as the blue growth revolution takes off and we start moving through them. So, the idea behind it is just kind of stepping stones where you jump from one to the next. You'll be vulnerable in the interim periods, whether the reserve actually functions as an effective protection area will really depend on that balancing act between how long you reside in any one of these reserves that are set aside versus the transitory zone where you are vulnerable and unprotected".
	6	"Well the idea that there's a bunch of marine protected areas which there was some cohesive planning around".
	7	"Well the way I see a network is that it is a collection of individual MPAs. That's not necessarily an Oceans Act marine protected area, it could be others. They would operate cooperatively and synergistically at various spatial scales with a range of protection levels and that would be to fulfill the ecological aims of the network effectively and comprehensively more than individual sites could be alone. The outcome is greater than the sum of its parts. That's the idea".
	8	"Group of marine protected areas. Hypothetically they are all supposed to work together".
	9	"A network, of course, is several, especially smaller ones, that are created in a context, or hopefully around a context, like larval dispersal or connectivity regarding spawning, nursery, feeding areas for certain species".
	10	"A network is when you have more than one and they are designed for a variety of reasons. The network captures the representivty, the connectivity, and the precautionary aspect of replicability and having more than one area protected".
	11	"I used the term system because that was more of a terrestrial kind of term, but at DFO we use the term network, but I use the two, I think they're the same thing. So basically, it's, you know, a collection of marine protected areas that are connected through ecological processes, that's another very simple version. I know there's much more elaborate definitions, but in my mind it's just the connectivity or the connectedness of the network is really what makes it a network".
	12	"A network means that those MPAs are linked ecologically to each other. I think that's sort of the simple definition".
	13	"I want to differentiate between a portfolio of marine protected areas, so I'll start with that. A portfolio is what a lot of nations are calling a network, it's basically a group of marine protected areas or whatever they are going to call them, some sort of sanctuary zone or whatever. They are areas that have been selected and it's a portfolio because

		there's more than one, they may be close together they may not, they may share some similarities in the features they protect, they may not. So, what's happened now is with this marine protected area network idea is a lot of people are taking these groups of single protected areas, these portfolios, and calling them networks. The reason why I categorize that as different is because when we think of a network what we're essentially getting at is the idea of having connectivity between them".
	14	"Maybe, sometimes, when people say marine protected area system, they're not necessarily talking about connected protected areas. So, like in Canada, now, maybe you could say we have a marine protected area system because we do have MPAs; we just don't have an MPA network; there's no connectivity".
	15	"So a network would be a ... is a ... it is a whole bunch of MPAs which actually all contribute to a larger conservation objective, so the purpose being that each of the ... no one MPA is accomplishing what the network objective is, but that collectively the MPAs serve to accomplish that conservation objective".
	16	"Well a network of marine protected areas would be a compilation of sites that are um... that work together, that in a synergistic manner, that offer greater benefits to conservation than any one site could offer alone or um... each site could offer independently. The network um... of MPAs should adhere to certain criteria such as providing um... connectedness or connectivity between marine protected areas and also be ... sites should be selected depending upon the adequacy of the site, the viability of the site, resilience of the site um... representative nature of the site".
	17	"So, I guess I would see that the network would have to have a sense that there is connectivity involved. Why you have a network is that either its larval dispersal or pelagic species, or its a number of spawning grounds or something else, but something that needs to have connectivity is why you would have a network". "But I would say the network needs to have connectivity at its basis…"

APPENDIX G – MPA DEFINITION COMPONENTS (DAY ET AL. 2012).

Phrase	Explanation provided in the 2008 Guidelines	Discussion and example of application in the marine realm
Clearly defined	*Clearly defined implies a spatially defined area with agreed and demarcated borders. These borders can sometimes be defined by physical features that move over time (e.g., river banks) or by management actions (e.g., agreed no-take zones).*	This implies that MPAs must be mapped and have boundaries that are legally defined. However, while some MPAs can be clearly defined (e.g. an entire bay bounded by headlands), for others it may be difficult to mark the boundaries, especially if the MPA is offshore. Even boundaries on the landward side, where tide levels can be used (e.g. Low Water Mark), can be difficult to establish (see Box 1). Increasingly, MPA or zone boundaries are defined by high resolution latitude and longitude coordinates, as determined by modern GPS instruments. **Example:** • The US National Marine Sanctuary System identifies sanctuaries legislated under the National Marine Sanctuaries Act with boundaries defined in a series of associated maps.
Geographical space	*Includes land, inland water, marine and coastal areas or a combination of two or more of these. "Space" has three dimensions, e.g., as when the airspace above a protected area is protected from low-flying aircraft or in marine protected areas when a certain water depth is protected or the seabed is protected but water above is not: conversely subsurface areas sometimes are* not *protected (e.g., are open for mining).*	All protected areas exist in three dimensions, but the vertical dimension in MPAs is often a substantial management consideration. In MPAs, management may need to address the airspace above the sea surface, the actual water surface, the water column (or parts of it), the seabed and the sub-seabed, or just one or a combination of two or more of these elements. For example, some MPAs protect just the seabed/benthos and not the water column above. It is therefore important that an MPA has a clear description of the dimensions that are actually protected. **Examples:** • In Australia's Great Barrier Reef Marine Park, the boundary is clearly defined by legal proclamation. The zones in the GBRMP are legally defined in the statutory Zoning Plan. The MPA goes to a depth of 1000 metres below the seabed and a height of 915 metres (airspace) above the surface of the water. • In Australia's Huon Commonwealth Marine Reserve in the South-east Marine Reserve Network, zoning is stratified by depth. Within the benthic sanctuary zone, the seabed and adjacent waters are fully protected. Above this, commercial fishing activity is allowed in the water column from the sea surface down to 500 metres depth.

Recognised	*Implies that protection can include a range of governance types declared by people as well as those identified by the state, but that such sites should be recognised in some way (in particular through listing on the World Database on Protected Areas – WDPA).*	**Example:** • The Government of Canada and the Council of the Haida Nation co-manage Gwaii Haanas National Park Reserve and Haida Heritage Site, and the

		Gwaii Haanas National Marine Conservation Area Reserve off the Pacific coast of Canada.
Dedicated	*Implies specific binding commitment to conservation in the long term, through e.g.:* • *International conventions and agreements* • *National, provincial and local law* • *Customary law* • *Covenants of NGOs* • *Private trusts and company policies* • *Certification schemes*	**Examples:** • The Galápagos Marine Reserve is designated under national law and is also an integral part of the Galápagos Islands World Heritage Site. • Vueti Navakavu in Fiji is a locally managed marine area (LMMA) established by the community and declared through local cultural protocol systems.
Managed	*Assumes some active steps to conserve the natural (and possibly other) values for which the protected area was established; note that "managed" can include a decision to leave the area untouched if this is the best conservation strategy*.	The requirement that a site is managed applies to both marine and terrestrial situations. As on land, many types of MPA management are possible. **Example:** • Bonaire National Marine Park in the Netherlands Antilles has clearly defined regulations that apply to all users of the park.
Legal or other effective means	*Means that protected areas must either be gazetted (that is, recognised under statutory civil law), recognised through an international convention or agreement, or else managed through other effective but non-gazetted, means, such as through recognised traditional rules under which community-conserved areas operate or the policies of established non-governmental organisations*.	As for terrestrial protected areas, 'effective means' include agreements with indigenous groups; **Example:** • Dhimurru Indigenous Protected Area, an area of land and sea in the Northern Territory of Australia, on the Gulf of Carpentaria, is run by the Dhimurru Land Management Aboriginal Corporation which works with the Traditional Owners to manage the protected area.
... to achieve	*Implies some level of effectiveness – a new element that was not present in the 1994 definition but which has been strongly requested by many protected area managers and others. Although the category will still be determined by objective, management effectiveness will progressively be recorded on the WDPA and over time will become an important contributory criterion in identification and recognition of protected areas*.	As for terrestrial protected areas, this implies some level of effectiveness and therefore requires that the MPA is subject to monitoring, evaluation and reporting. **Example:** • The assessment of management effectiveness of the Aldabra World Heritage Site in the Seychelles, undertaken as part of the Enhancing our Heritage project with the UNESCO World Heritage Centre, provides information on the extent to which the objectives of this MPA are being achieved.
Long term	*Protected areas should be managed in perpetuity and not as short term or a temporary management strategy*.	As with terrestrial protected areas, long-term protection (over timescales of human generations) is necessary for effective marine conservation. Seasonal closures of an area for a specific purpose (such as fish spawning, whale breeding, etc), in the absence of any additional biodiversity protection and any primary nature conservation objective are not considered to be MPAs. Seasonal protection of

		certain species or habitats may be a useful component of management in an MPA. **Examples:** • The Cockle Bay Shellfish Seasonal Closure area in New Zealand is NOT an MPA as it is only in force for the months of October to April when collection of shellfish is banned. • In the Marine Mammal Protection Zone of the Great Australian Bight Marine Park (Commonwealth Waters) the use of vessels is prohibited 1 May - 31 October each year to protect an important calving and breeding area for Southern Right Whales.

Conservation	*In the context of this definition conservation refers to the* in situ *maintenance of ecosystems and natural and semi-natural habitats and of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties*	**Examples:** • Ecological Reserves in the Florida Keys National Marine Sanctuary in the United States are designed to provide natural spawning and nursery areas for the replenishment and genetic protection of marine life and aim to protect and preserve all habitats and species found throughout the Sanctuary. • The inclusion of a minimum of 20% of all 70 bioregions within Australia's Great Barrier Reef Marine Park is designed to provide in situ protection of representative examples of all species and ecosystem processes.
Nature	*In this context nature always refers to biodiversity, at genetic, species and ecosystem level, and often also refers to geodiversity, landform and broader natural values.*	All protected areas, whether terrestrial or marine should aim to protect all the features of conservation importance within their boundaries. **Example:** • The overall objective of the Great Barrier Reef Marine Park is to provide for the long term protection and conservation of the **environment, biodiversity and heritage values** of the Great Barrier Reef Region.
Associated ecosystem services	*Means here ecosystem services that are related to but do not interfere with the aim of nature conservation. These can include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services* *such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits.*	MPAs provide a wide range of ecosystem services: **Examples:** • Ecosystem services: The MPA network in Belize has been estimated to contribute nearly US$20 million annually in reef-related visitor expenditure. • Regulating ecosystem services, for example seagrass meadows, mangroves and kelp forests as carbon sinks: The four MPAs designated by the Malta Environment and Planning Authority to protect Malta's *Posidonia* (seagrass) beds together protect over 80% of this habitat in Malta.

		Areas set up for wave/wind power are generally NOT MPAs (see section 2.3).
Cultural values	*Includes those that do not interfere with the conservation outcome (*all *cultural values in a protected area should meet this criterion), including in particular:* • *Those that contribute to conservation outcomes (e.g., traditional management practices on which key species have become reliant)* • *Those that are themselves under threat.*	Areas set aside for cultural values are only protected areas under the IUCN definition, if they have nature conservation as a primary aim. However, many MPAs contain sacred sites or have significant cultural and heritage value and understanding of this is important. **Examples:** • Nosy Ve, an island in southern Madagascar protected under a local 'dina' agreement is both a sacred site and an area important for corals and as a tropic bird nesting colony. • Papahanaumokuakea Marine National Monument in the North West Hawaiian Islands is important for Native Hawaiians at genealogical, cultural, and spiritual levels.