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Considerations for Identification of Effective Area-based Conservation Measures

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

This report presents relevant material to inform a June 2015 DFO National Science Advisory meeting to produce a science-based consensus interpretation of the phrase, and associated guidance on reporting on: “Percentage of total coastal and marine territory conserved in marine protected areas and other effective area-based conservation measures” in Canadian marine waters, with emphasis on informing evaluation of what constitutes an effective area-based conservation measure. We present the current framework of the International Union for the Conservation of Nature (IUCN) and Canadian Council on Ecological Areas (CCEA) for reporting on this indicator and challenge some of the assumptions embedded in their approach. It is recommended that empirical evidence of “conservation benefits” be provided when evaluating effectiveness whenever possible. In cases where such evaluations cannot be made we present a selection of ecologically based factors, drawn from a literature review, which when present can infer that the area has been effective at achieving its conservation goals. None of the reviews concluded that any individual factor was either necessary or sufficient to ensure conservation of biodiversity, but each could contribute to conservation of some or many aspects of biodiversity if applied in an appropriate manner. Therefore, it is concluded that scientifically sound decisions about what to include as areas where “other effective area-based conservation measures” are in place, will have to be done on a case by case basis for the different types of areas where spatial measures are in effect.

Facteurs à prendre en compte pour déterminer les mesures de conservation efficaces par zone

RÉSUMÉ

Ce rapport présente des renseignements pertinents pour étayer le constat de la réunion de consultation scientifique nationale du MPO de juin 2015 visant à donner une interprétation scientifique commune de la phrase « pourcentage du territoire côtier et marin total conservé grâce à l'établissement de zones de protection marine et à d'autres mesures de conservation efficaces par zone » dans les eaux canadiennes, ainsi que les directives connexes sur l'établissement de rapports, en s'assurant que l'évaluation prenne en compte ce qui constitue une mesure de conservation efficace par zone. Nous présentons les cadres actuels de l'Union internationale pour la conservation de la nature (UICN) et du Conseil canadien des aires écologiques (CCAE) qui doivent être suivis pour établir des rapports sur cet indicateur, et mettons en question certaines des hypothèses sous-entendues dans leur approche. Il est recommandé de donner des preuves empiriques des « avantages de la conservation », dans la mesure du possible, lors de l'évaluation de l'efficacité. Pour les cas où de telles évaluations ne peuvent être réalisées, nous présentons une série de facteurs d'importance écologique, tirés d'une analyse documentaire, qui permettent de déduire, lorsqu'ils sont présents, que la zone a été efficace. Aucune des évaluations n'a permis de conclure que l'un ou l'autre des facteurs est nécessaire ou suffisant pour assurer la conservation de la biodiversité; elles ont cependant déterminé que chaque facteur peut contribuer à la conservation de certains ou de plusieurs aspects de la biodiversité s'il est appliqué d'une façon adéquate. Par conséquent, on en conclut que les décisions fondées sur des données scientifiques, concernant les éléments à inclure dans les zones où « d'autres mesures de conservation efficace par zone » sont en place, devront être prises au cas par cas, selon le type de zone où des mesures spatiales existent.

INTRODUCTION

In order to provide consistent and relevant reporting on national and global biodiversity targets, it is essential to have a common understanding of what to include when calculating the performance indicators, in this case, the percentage of areas meeting the standards for reporting under CBD Target 11; that is a marine area receiving effective area-based conservation. The development of the definitions of what constitutes a protected area has taken place elsewhere and we provide a background of that literature, highlighting those definitions that are currently being used both internationally and domestically. It is clear from these definitions that areas other than MPAs[1] should be considered as receiving some degree of protection with wholly or partially spatial measures. This was explicit in the original Aichi biodiversity targets, which were negotiated with the full understanding that Parties would be allowed to include a range of areas when reporting against that target, as long as the biodiversity in the areas was being effectively conserved with spatially-based measures (J. Rice, pers. comm.); i.e., the "other effective area-based conservation measures". For the purposes of this document, protected areas and other effective area-based conservation measures are collectively referred to as *conservation areas*[2].

For DFO there is a need to have a consistent interpretation of the phrase "other effective area-based conservation measures" in relation to the goal of reporting biodiversity conservation outcomes. This issue has been discussed previously (e.g., Anon, 2013) although the focus has been largely from a conceptual perspective. This research document attempts to bring together relevant material to inform a June 2015 DFO National Science Advisory meeting which will produce a science-based consensus interpretation of the phrase, and associated guidance on reporting on: "*Percentage of total coastal and marine territory conserved in marine protected areas and other effective area-based conservation measures*" in Canadian marine waters. Any conclusions drawn within this working paper are interim conclusions drawn by the authors and are not meant to pre-empt the conclusions of the meeting.

This document is structured around three themes. The first theme is a review of the International Union for the Conservation of Nature (IUCN) and Canadian Council on Ecological Areas (CCEA) approaches to reporting on this biodiversity indicator and sets the background. The IUCN/CCEA approaches require an assumption that specific management structures are necessary *and sufficient* to lead to the outcomes that the managers intend. That assumption is challenged and further evidence is presented that some types of DFO conservation areas, such as closures for fisheries and other ecosystem functions and services, can fall into the same IUCN Category as MPAs created under the *Oceans Act*. This can occur both because MPAs may provide incomplete protection to biodiversity (for example because DFO does not have the mandate to exclude all activities in the ocean, (e.g. shipping) or because activity outside an MPA may be transported into an MPA and pose threats to biodiversity (e.g. land-based runoff of sediment or nutrients)) and also because conservation areas other than fully designated MPAs may exclude

[1] Throughout this paper the term "marine protected area" and acronym MPA will be reserved for Marine Protected Area designated by appropriate legislation, such as Canada's *Oceans Act* and similar legislation in other national jurisdictions. When referring collectively to protected areas and other effective area-based conservation measures,

[2] Environment Canada is recommending the use in Canada of the term "conservation areas". This is in line with material published by federal provincial-territorial governments on the 2020 Biodiversity Goals and Targets for Canada and conforms with 2015 guidance from UNEP WCMC on page 8 of the World Database on Protected Areas User Manual 1.0 which states, "For the purposes of this document, protected areas and other effective area-based conservation measures are collectively referred to as *conservation areas*."

or constrain a variety of activities that can detrimentally affect biodiversity if not effectively managed and hence meet the IUCN protected area definition.

A second theme, which follows from the first, develops the concept of the term “effective”. This report concludes that “effective” needs to be based on demonstrated biodiversity consequences of a measure(s), and that monitoring plans, programs and their review are an essential part of that evaluation. Only where management actions have been shown to be effective can one provide meaningful data for the indicator. However evaluation of effectiveness, within a sound scientific framework, may be impractical or impossible given the history of a specific closure. Nevertheless, O’Boyle (2011) was able to provide evidence for effectiveness of 7 closed areas in Atlantic Canada, which were put in place under differing management structures.

The third theme follows on this, which is a review of characteristics of conservation areas, usually MPAs, of a variety of types and management approaches that are intended to make them successful. This review includes an evaluation of the ability to infer “effectiveness” from the presence or absence of those properties and the circumstances that modify their effectiveness. This draws on the same mechanistic premise of the first theme except that the guiding principles are drawn from evidence-based science rather than just derived from policy choices.

BACKGROUND

The Anthropocene epoch has been marked by a general decline in biological diversity (Pereira et al., 2010) that could have abrupt and irreversible consequences for global ecosystem functioning (Barnosky et al., 2012). In 1992, the Convention on Biological Diversity (CBD) was negotiated and adopted to address this issue. The CBD is a legally binding treaty, currently ratified by 196 parties, including Canada, although its legal power was intentionally limited with a clear enunciation of national control over domestic biological resources (United Nations General Assembly, 1992):

> *“States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own natural resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or areas beyond the limits of national jurisdiction.”*

The CBD through its Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) provides the Conference of the Parties (COP) and, as appropriate, its other subsidiary bodies, with timely scientific and technical advice relating to the implementation of the Convention but refrains from making any prescriptive policy or management recommendations.

At the 6th meeting of the COP of the CBD in 2002, decision VI/26 adopted a Strategic Plan for more effective implementation of the objectives of the Convention. The goal of the plan was to achieve, by 2010, a significant reduction in the rate of biodiversity loss at global, regional, and national levels. The CBD’s 2010 targets were not met. At the 9th meeting of the COP, held in 2008, decisions were made to review and update biodiversity targets as part of the process of revising the Strategic Plan beyond 2010. In November 2010, at the 10th meeting of the COP, held in Nagoya, Aichi Prefecture, Japan, the Parties adopted a revised and updated Strategic Plan for Biodiversity (Harrop, 2011), including the Aichi Biodiversity Targets, for 2011-2020 (COP 10 decision X/2).

The mission of that Strategic Plan for Biodiversity (COP 10 Decision X/2 Annex) was to:

> *“…halt the loss of biodiversity in order to ensure that by 2020 ecosystems are resilient and continue to provide essential services…”*

Five strategic goals and 20 time-bound, measurable biodiversity targets were negotiated (Table 1), with the expectation that decision-making would be based on sound-science and the precautionary approach (COP 10 Decision X/2 Annex). These are referred to as the **Aichi Biodiversity Targets**.

In February 2015 Canada released national biodiversity goals and targets for 2020 (Table 2), in accordance with Article 6 of the CBD General Measures for Conservation and Sustainable Use, which calls on each contracting party to:

> *"(a) Develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned; and*
>
> *(b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies."*

The Canadian goals and targets were informed by the Canadian Biodiversity Strategy [PDF] and the Biodiversity Outcomes Framework [PDF]. The Canadian goals and targets closely reflect those of the Aichi Biodiversity Targets but are formulated with respect to the domestic context.

Aichi Biodiversity Targets

Strategic Goal A: *Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society*

Strategic Goal B: *Reduce the direct pressures on biodiversity and promote sustainable use*

Strategic Goal C: *To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity*

Strategic Goal D: *Enhance the benefits to all from biodiversity and ecosystem services*

Strategic Goal E: *Enhance implementation through participatory planning, knowledge management and capacity building*

Aichi Biodiversity Target 11, which falls under Strategic Goal C (Table 1) states:

> *"By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures and integrated into the wider landscapes and seascapes."*

Canada's National Biodiversity Target 1 which falls under Goal A (Table 2) states:

> *"By 2020, at least 17 percent of terrestrial areas and inland water, and 10 percent of coastal and marine areas, are conserved through networks of protected areas and other effective area-based conservation measures."*

These targets (Aichi Biodiversity Target 11 and Canada's National Biodiversity Target 1) are sufficiently similar that reporting for the domestic target would satisfy the reporting requirements for the CBD as was intended (Anon, 2013). The CBD has provided technical guidance for implementation of the Aichi Biodiversity Targets, including Target 11 (Table 3), while Canada has identified indicators for each national target, which will serve to evaluate status and trends in biodiversity in Canada and be used to report on progress toward the domestic targets as well as Canada's contribution toward the CBD Strategic Plan.

The indicator for ***Canada's National Biodiversity Target 1*** (Aichi Biodiversity Target 11) (Table 4) related to coastal and marine areas is:

"Percentage of total coastal and marine territory conserved in marine protected areas and other effective area-based conservation measures."

Forward reference to "performance indicator" in this document refers to this indicator.

PROTECTED AREA CATEGORIES AND DEFINITIONS

The International Union for the Conservation of Nature / World Commission on Protected Areas (IUCN/WCPA) is an international non-governmental organization (NGO) with observer and consultative status at the United Nations. Over 1200 governmental and non-governmental organizations are members and approximately 11,000 scientists and experts participate in their work. The IUCN has been actively involved in the implementation of international conventions on nature conservation and biodiversity (Dudley, 2008). The IUCN definition (Dudley, 2008) of a protected area, which is meant to apply to marine, freshwater and terrestrial sites, 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."

This is the current operating definition used by the IUCN and applies to all ecosystems, including marine ones. The IUCN formerly defined a **marine** protected area (IUCN, 1988) as:

"Any area of intertidal or subtidal terrain, together with its overlying waters and associated flora, fauna, historical and cultural features, which has been reserved by legislation to protect part or all of the enclosed environment."

That was later amended (IUCN, 1994) to:

"An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means."

The amendment removed the requirement for legislation, and indeed for any legal foundation for the area's management, but narrowed the definition to only include areas dedicated to the protection of biodiversity, as one objective (if more than one, "*especially*" dedicated implies the biodiversity objective is not subordinate to others). This is referred to as the "supplemental marine protected area definition" (Government of Canada, 2011) [3].

The IUCN developed standardized guidelines for protected area designation based on conservation objectives, the degree of protection, and naturalness (Dudley, 2008). These IUCN categories (Table 5), which were reviewed and updated in 2014, are recognized by the United Nations in their List of Protected Areas (Deguignet et al., 2014) and by many national governments as the global standard for defining and recording protected areas, although there is inconsistency in how they have been applied (Leroux et al., 2010). The IUCN Categories have been recognized by Canada in the *National Framework for Canada's Network of Marine Protected Areas* (Government of Canada, 2011). There are six different categories (Dudley et al., 2013):

I.

   a. Strict Nature Reserve: "strictly protected areas set aside to protect biodiversity and also possibly geological/ geomorphological features, where human visitation,

[3] When the Aichi target 11 was negotiated, for some Parties it was the possibility of a narrow interpretation of "especially dedicated" that led to inclusion of the phrase "and other effective area-based conservation measures" in the target (J. Rice, pers comm.)

use and impacts are strictly controlled and limited to ensure protection of the conservation values."

   b. Wilderness Area: "protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition."

II. National Park: "protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities."

III. Natural Monument or Feature: "protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove."

IV. Habitat/Species Management Area: "protected areas aim to protect particular species or habitats and management reflects this priority."

V. Protected Landscape / Seascape: "protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values."

VI. Protected area with sustainable use of natural resources: "protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems."

In theory, the degree of naturalness in these categories, ranging from the most natural to the least natural condition is: Ia = Ib > II = III > IV = VI > V (Dudley, 2008). This ranking is relevant to our concerns to the extent that one is able to infer that if an area is highly "natural" then it has received protection from threats and therefore is "effective" at protecting biodiversity. If surrounding areas have been degraded by threats that were prevented or managed by the measures intended to protect the area, then the inference may be sound. However areas may be "natural" on many ecological criteria because they have just not been exposed to the threats for some reason (often but not exclusively due to remoteness or inaccessibility), and if the areas were exposed to those threats the management measures in place may not provide "effective protection" at all. On the other hand, small but highly protected areas may not be very natural because activities outside the areas affect biodiversity within them, or because such areas may have been highly perturbed before protection was implemented, and the areas have not recovered to a "natural" state. Consequently, the size of a spatial closure does not necessarily equate with either effectiveness or naturalness.

Environment Canada (which is the focal point for Canada in CBD-related matters), DFO and Parks Canada have been engaged in discussions held by the Canadian Council on Ecological Areas (CCEA), a federal-provincial-territorial-stakeholder council, on the development of guidance for reporting on the biodiversity target. The CCEA is a member of the IUCN and, in partnership with Environment Canada, maintains the national data base on Conservation Areas Reporting and Tracking System (CARTS), used by all federal, provincial and territorial protected area and park agencies in Canada to report on protected-area systems across Canada. Following extensive consultation with its members and collaborators, all of whom work in protected areas agencies and organizations or otherwise possess considerable expertise in the field, CCEA prepared a set of guidelines which can be used to apply the IUCN protected area management categories to protected areas in Canada (Anon, 2008: see Table 5). The guidance document has a section on marine protected areas, though it acknowledged that less attention had been given internationally to providing guidance on their categorization. Those CCEA guidelines (Anon, 2008) state that:

> *"Marine protected areas should meet both the original IUCN protected area definition and the supplemental marine protected area definition. Some marine protected areas may contain zones that do not meet these basic definitions."*

The IUCN protected area definition (Dudley, 2008) is once again:

> *"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."*

…whilst the supplemental marine protected area definition (IUCN, 1994) referred to by the CCEA (Anon, 2008) is:

> *"An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means."*

The CCEA guidelines also make the important point that, for many marine areas, there can be different degrees of protection applied to the water column (e.g., Maxwell et al., 2014) and the seabed. The IUCN has also noted that vertical zoning creates a challenge for spatial reporting and potential confusion among marine users about restrictions. Hence, different IUCN categories may apply to the same area at different depths or in different zones of the seabed[4]. In such cases, both IUCN and CCEA recommend classifying the area according to the lowest category of protection in the column.

Table 5 compares the IUCN categories and descriptions to the corresponding categories listed by the CCEA and DFO (fisheries closures and protected areas). Only one example of an *Oceans Act* MPA was listed in the CCEA guidelines and therefore classified by CCEA participants. The Eastport Marine Protected Area (Round Island & Duck Islands) in Bonavista Bay, NL is cross-referenced to IUCN Category IV and is described as being protected in legislation by the *Fisheries Act*, the *Oceans Act* and the *Species-At-Risk Act* (Anon, 2008). Most, if not all, of DFO's year-round fisheries closures would also fit into this category (Table 5). Conversely, it would be difficult for a DFO closed area (MPA or other) to fit into Categories I or II as DFO does not have the mandate to regulate all marine activities. Therefore a DFO management plan for an MPA cannot regulate all threats, unless there is willing cooperation from other federal departments (and often Provinces and Territories). As such, the tabulation has limited effectiveness at distinguishing the range of closed areas that meet the IUCN protected area definition (Dudley, 2008) and that are managed by the department.

MARINE PROTECTED AREAS

Formal marine protected areas (MPAs) in Canada are those established under the *Oceans Act*, the *Canada National Marine Conservation Areas Act*, the *Canada Wildlife Act* or other statutes[5]. They have legal protection status, and their status and boundaries are published in the Canada

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[4] It is also possible that in large MPAs, their management plans may give different degrees of protection to different subareas of the MPA (either seabed or water column, or both), as in the case in, for example the Great Barrier Reef. This has happened in Canada in the Gully MPA where different areas are zoned with different degrees of protection and this is not precluded under the *Oceans Act*.

[5] These would be provincial/territorial for example, and would also include single case legislation like the *Saguenay-St. Lawrence Marine Park Act*.

Gazette. Hence, they can be unambiguously and spatially defined. A minimum interpretation of the indicator for Canada's National Biodiversity Target 1 from a policy perspective would be that the area of all such MPAs should be included when calculating the percentage of total coastal and marine territory conserved.

On scientific grounds, it does not follow from their legal status alone that even if all MPAs contribute to Canada's Goal A (under which Target 1 is nested), that all MPAs were necessarily created **primarily** to produce biodiversity conservation outcomes. In fact the phrase "conserve biodiversity" may not appear in their stated objectives. For example the objective of the Eastport, NL MPA is: To maintain a viable population of American Lobster through the conservation, protection, and sustainable use of resources and habitats within the EPLMA (Eastport Peninsula Lobster Management Area); and to ensure the conservation and protection of threatened or endangered species (DFO, 2013). Success is measured by increased productivity and abundance of lobster in the surrounding fishery. The measures implemented to achieve conservation, protection and sustainable use of lobsters may indeed also conserve and protect additional marine biodiversity (including but not solely, threatened and endangered species), but if demonstrated, such outcomes would be *co-benefits* of the primary objective and not part of it.

> Article 2 of the CBD: *"Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.*

In reality, with regard to Goal 1, under the CBD, there is considerable latitude in the range of outcomes that can be considered as contributing to the "conservation of biodiversity" (see text box), and even single species protection does constitute protection of biodiversity. Moreover, if the co-benefits can be demonstrated to be following from the measures implemented to achieve the primary objective of conserving a specific species, these also come within the scope of Article 2 of the Convention. Therefore, it is not necessary that biodiversity be explicitly stated as the primary conservation objective of an MPA if *de facto* the objectives fit the CBD definition of biological diversity, and the measures implemented do successfully conserve, protect and ensure uses of it are sustainable.

SPATIAL CLOSURES UNDER THE *FISHERIES ACT*, *OCEANS ACT* AND *SPECIES AT RISK ACT*

MPAs, which are created by regulation under the Oceans Act, are far from the only spatial management measure applied in the marine environment. DFO has a number of areas with spatial restrictions to different activities (hereafter referred to as closed areas) implemented under the Fisheries and Species at Risk Acts with potential to qualify as "other effective area-based conservation measures".

Closures under the *Fisheries Act*:

- p. 28/29 = Fishery schedule closure times/areas
- Areas closed to protect benthic species and habitats (e.g. coral conservation areas)
- Areas closed to protect areas used by marine mammals and SAR
- Areas closed to protect spawning areas of commercial fish
- Areas closed to protect juveniles of commercial fish
- Seasonal closures (e.g. April 1st – December 31st).
- Rockfish conservation areas (RCAs)
- Shellfish contamination closures (SCCs)
- Prohibition for contaminated fisheries regulations

Closures under the *Species at Risk Act:*

- Critical Habitat

These measures generally prohibit fishing from occurring in an area for various reasons, although in some cases only the use of specific gears is prohibited, and fishing with other gears may be allowed.

For each of these areas effectiveness is a qualifier for inclusion in the calculations of the performance indicator for reporting under the targets. Notably, few of the areas that fall under this umbrella have been explicitly created for the conservation of biodiversity. Nevertheless, the objectives of many likely fall within the broader understanding of the term in the formal CBD sense, which is that embodied in the Aichi targets. Moreover, there may be instances where effective conservation of biodiversity is a "co-benefit" of measures adopted primarily for another reason.

In all cases (i.e., for MPAs and other spatial closures), there are a series of questions to pose relative to reporting on Aichi Target 11 (Canada Target 1). The first is whether or not conservation of biodiversity is a stated objective for an area to which an area-based conservation measure is applied. A second, in cases when conservation of biodiversity is not an *explicit* stated objective, is whether or not biodiversity co-benefits could reasonably be expected if the stated objective(s) is being achieved. In either case, a third question is whether the available evidence shows that at least some aspects of biodiversity[6] are actually receiving some conservation or protection benefits from the measures put in place. If this sequence of questions is not pursued then there are risks either that areas where long-term conservation of biodiversity is being achieved are not recognized appropriately, or that areas intended to receive protection of biodiversity are not receiving the desired benefits through some combination of its location and spatial dimensions, its intended duration, or its regulations.

DEFINING "EFFECTIVE"

The English definition of the word effective (Oxford English Dictionary, 2008), i.e.:

> *"successful in producing a desired or intended result"*

…involves the evaluation of an outcome. The issue of what makes MPAs and "other effective area-based conservation measures" effective at conservation of biodiversity has been reviewed in the scientific and policy literature and these reviews provide a set of standards that are reviewed here.

EFFECTIVE CONSERVATION MEASURES AS DEFINED BY THE CCEA

In 2013, a CCEA workshop was tasked with reaching a consensus on defining "other effective area-based conservation measures" (OEABCMs). They agreed to five statements to describe the major characteristics that such areas should have in order to be recognized as contributing to Aichi Target 11 and hence to Canada's National Biodiversity Target 1. Those were (Anon, 2013):

1. Purpose of area-based measure / intention

[6] It should be recognized that NO spatial conservation measures protect ALL biodiversity. For example often early successional species are replaced by more climax species in highly protected areas (this may actually be a primary intent of the protection), and management plans may even call for active suppression of some species, particularly non-native species, to favour the preferred "natural" biodiversity.

“Areas included under Target 11 as OEABCMs must have an expressed purpose to conserve nature (biodiversity). We understand that this purpose might be achieved as a co-benefit of other management purposes or activities.”

2. Long term

“Areas included under Target 11 as OEABCMs must be managed for the long term to be effective. We accept a working definition of long term to mean there is an expectation that conservation will continue indefinitely[7].”

3. Importance of nature conservation objectives

“In areas included under Target 11 as OEABCMs, in cases of conflict with other objectives, nature conservation objectives shall not be compromised.”

4. Nature conservation outcomes

“Areas included under Target 11 as OEABCMs should result in effective and significant nature (biodiversity) conservation outcomes. When there are existing measures/areas that are to be considered as OEABCMs, evidence of conservation outcomes should be used as part of the screening process.”

5. Strength of conservation measures

“Areas included under Target 11 as OEABCMs should have a management regime that, through one or more measures that are effective alone or in combination, can reasonably be expected to be strong enough to ensure effective conservation, and if there are gaps, these will be addressed over time.”

In Statement 1 note that biodiversity = nature, which is neither the formal CBD definition, nor the one used by the CCEA elsewhere (see Table 6) and this discrepancy should be kept in mind through the other Statements as well. Further, Statement 4 only calls for evidence of benefits in the case of OEABCMs and not designated MPAs. There is no *scientific* basis for such a double standard, especially because, as will be highlighted later in this paper, the effectiveness of many MPAs globally has been questioned.

From these statements it is noted that conservation of biodiversity does not need to be an expressed purpose and can be a co-benefit of management actions (Statement 1) with high likelihood of security (Statement 2), and that evidence of conservation outcomes should be used to evaluate effectiveness (Statement 4).

Those characteristics were used by the CCEA to develop a draft Decision Screening Tool to guide the process of determining whether an area should be included towards the calculation of the value of the indicator for Aichi Target 11 (Anon., 2013). The description of the Tool states that priority was given to the long-term conservation of biodiversity, although how that assessment was made is unclear. It used 10 fields to categorize mechanisms that were equated with “effectiveness” (Table 6). Evaluation of effectiveness was colour-coded (Table 6) and subjectively determined. Following this ranking, a suite of additional characteristics were presented which could be incorporated into a decision tool or used for additional guidance (Table 7), however, these were not categorized by their “effectiveness” colour rating. The CCEA clearly places emphasis on management structure; i.e., the institution(s) and formal regulatory arrangements (including, if relevant, inclusive governance arrangements), which is typical of most assessments

[7] It was noted during the CCEA meeting that even legally based protection may be altered by future changes to legislation, and any area protected with spatial measures, including MPAs, would have to be reconsidered for inclusion if the measures were altered dramatically. It is this interpretation of “indefinitely” that was intended to be applied.

for Aichi Target 11 (Leverington et al., 2008), and not on evidence of conservation outcomes – although evidence of such outcomes can be used in some steps as ancillary information if it is available.

Linking Management Structure to Conservation Outcomes

There is no statement in the CCEA report (Anon., 2013) which explicitly addresses their fourth characteristic: *Nature conservation outcomes*, which is essential for defining effectiveness (Oxford English Dictionary, 2008). The draft decision tool assumes that if there is a biodiversity conservation objective in place and if regulations have been adopted to address any activities that could negatively impact the objective, then the conservation goals (including conservation of biodiversity) will be achieved. Several conditions have to be met for this is to be true, including:

i) there is a spatial match between the conservation area and the area of the activity (zone of influence of the activity) which affects achievement of the objective;
ii) the closed area must be large enough such that all areas which govern persistence of the biodiversity feature(s) in the objective, and activities which impact the feature(s), are included within its boundaries or somehow regulated outside the MPAs effectively enough that the objectives inside the MPA can be met. This can be practically applied in retention areas, for example, or for spawning and nursery areas for more mobile species;
iii) the regulation(s) and measures adopted for the MPA are actually likely to produce the desired changes in the activity(ies) being regulated, and the changes in the activities are sufficient to promote achievement of the objective(s);
iv) compliance with the regulations and measures is high (ideally full).

With regard to i) and ii), for most open systems the impact sphere may cover an area broader than the area closure, e.g., a small coastal MPA might be influenced by upstream events, land-based activities and/or inland water characteristics, giving different spatial delineations of the conservation area and the impact activity management area. In such cases, the conservation goals may not be met if persistence of the biodiversity in the closed (or otherwise spatially protected) area relies on other areas outside of the closed area. This has been recognized in the guidelines for developing networks of MPAs (e.g., Government of Canada, 2011) for addressing the 1992 CBD (Article 8a), which calls for “a system of protected areas” and explicitly recognizes connectivity in marine ecosystems, although it provides no definition of “connectivity nor methods for determining when adequate connectivity is achieved. There, the broader ecosystem connectivity network into which the area is linked must be intact (functional): this includes genetic connectivity but also spawning and other linked habitat such as feeding or nursery areas.

With regard to iii) and iv) similar assumptions were made for decades in fisheries management and came under serious question in the 1990s (Rice and Richards, 1996; Punt et al., 2014). The widespread adoption of Management Strategy Evaluations as an essential tool in successful objectives-based fisheries management (Punt et al., 2014) demonstrates how unwilling some management sectors are to assume that iii) and iv) are true without both empirical evidence and support from modelling. There is a lesson there for spatial management as well.

Marine Protected Areas

To further complicate the issue, the language of ***Canada's National Biodiversity Target 1*** (Aichi Biodiversity Target 11) indicator implies (through the words “other effective”) that MPAs are effective conservation measures. That is not necessarily the case. It cannot simply be assumed that all MPAs (or other closed areas) are effective at achieving their conservation outcomes based on their regulations alone; however the data needed to determine whether they have been effective or not may be lacking.

Edgar et al. (2014) conducted a global review of 87 MPAs worldwide and evaluated properties which conferred the greatest conservation benefits. They showed using random forest prediction models that the conservation benefits increased exponentially with the accumulation of five key features:

1) no take regulations
2) efficient and effective enforcement
3) old age (>10 years)
4) large area (> 100 km2) and
5) isolation (in their examples reefs isolated by deep water or sand).

They found that 59% of the MPAs studied were not ecologically distinguishable from fished sites and possessed only 1 or 2 of the key features noted above. Only 4 of the 87 MPAs possessed all five key features, while another 5 possessed 4 of them. With those 9 MPAs accounting for only 10% of the total MPAs surveyed, the authors concluded that the proportion of effective MPAs worldwide is likely much smaller than currently thought. Edgar et al.'s review is not the first to make this point and the lack of effectiveness of many MPAs has also been identified by others (cf., Jameson et al., 2002).

ASCRIBING 'CONSERVATION BENEFITS'

There is ample evidence that effectively closed areas, whether MPAs or other, can lead to increased diversity in all targeted ecosystem components (Halpern, 2003 (based on a review of 89 studies); Lubchenco et al., 2003; Lester et al., 2009), added the provision that the closures are of more than temporary duration and that management is effective. Abundance and productivity of the area are also frequently enhanced (Syms and Carr, 2001; O'Boyle, 2011). Consequently, **permanent or long term closures have more potential for biodiversity conservation than short-term measures, if they result in the removal or reduction of disturbances**. O'Boyle (2011) describes these as "collateral benefits" and assessed seven spatial closures in Atlantic Canada for their conservation and collateral benefits (Table 8).

Potential benefits of effectively closed areas include increased abundance and biomass of species, age/size composition, spawning stock biomass, increase in spillover and larval supply, increase in yield of target species, restoration of trophic guilds, conservation of biodiversity, conservation of critical habitat, protection of species, and availability of undisturbed opportunities for scientific research or collection of baseline data (e.g., Bohnsack, 1993; Bohnsack and Ault, 1996).

It is also important to keep in mind the point made earlier that no management measure can benefit all biodiversity. Biodiversity "benefits" are always in the context of some desired states. These are often states that are more "natural" or have a greater abundance of a rare or valued species. The large literature debating how and under what conditions conservation areas contribute to fisheries management (e.g., Rice et al., 2012) documents that a species may be "valued" for very pragmatic reasons, as is in the case of the Eastport MPA discussed earlier. Therefore when "conservation benefits" of a closed area are discussed, an informed debate must both specify which aspects of "biodiversity" are intended (or observed) to benefit from the protection, and to apply serious efforts to assess what aspects of biodiversity may be negatively impacted by increases in the biodiversity components that are intended to benefit from the protection.

Evidence Base

Demarcating an area and removing/reducing threats to biodiversity without ascertaining conservation benefits or, as the CCEA frames it, a nature conservation outcome, can give an inaccurate view of the status of biodiversity conservation. Effectiveness needs to be evaluated with respect to stated objectives and targets (Day et al., 2002). Such assessments allow managers to re-evaluate their management plans and to amend them to improve performance (Hocking et al., 2006). When evaluating conservation of biodiversity, it is also important to evaluate outcomes (even if un-intended) in order to determine whether there are co-benefits and how “strong” the co-benefits are, and if there are unexpected changes in biodiversity that are undesirable or contrary to overall management objectives for the area (“negative co-benefits”).

Ferraro and Pattanayak (2006) make the important point that management actions that are put in place to protect biological diversity require the same scientific rigor in evaluating their effectiveness that we invest in testing ecological hypotheses. They contend that:

> *“…our understanding of the way in which policies can prevent species loss and ecosystem degradation rests primarily on case-study narratives from field initiatives that are not designed to answer the question “Does the intervention work better than no intervention at all?”*

Building on that study, Maron et al. (2012) defined a conservation benefit as:

> *“The benefit (or additionality) attributable to a conservation action is the difference between the outcomes of two scenarios: (1) the scenario with the conservation action, and (2) the alternative scenario, in which action did not occur.”*

This definition allows for natural variation to occur in non-linear ways without prejudicing the assessment of “benefit”. Assessment under this definition of conservation benefit involves a before-after-control-impact (BACI) design to account for natural change before and after a treatment (e.g., Winberg and Davis, 2014).

Donlan et al. (2013) similarly defined a ‘conservation benefit’ relevant to the United States *Endangered Species Act* but further stated that when determining whether the net benefit standard is met, the “benefits and harms should be evaluated using the same biological metrics”. Game et al. (2008) successfully used this analytical approach to prioritize the selection of marine protected areas on the Great Barrier Reef for protection from cyclones. The Maron (2012) definition of conservation benefit (text box), and variations thereof, is preferable to less operational definitions such as the IUCN definition (IUCN, 2013):

> Conservation benefit: *The benefit attributable to a conservation action is the difference between the outcomes of two scenarios:*
>
> *1) the scenario with the conservation action, and*
> 2) *the alternative scenario, in which action did not occur.* Maron et al. (2012)

> *“…this [conservation benefit] will usually comprise improving the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functions or processes.”*

However, it is recognized that it can be difficult to effectively quantify the alternative scenario unless suitable experimental controls exist or a monitoring plan was put in place at the time of the establishment of the closed area, with adequate baseline data collected. Evaluation of alternative scenarios will be increasingly more difficult for larger conservation areas, or closed areas which encompass unique features or occur in unique areas. Nevertheless, conceptually it is the change in biodiversity resulting from the additional management measures implemented for conservation and protection that are the measure of “effectiveness”. That measure of effectiveness can be applied with equal practicality to the measures in the MPA management plan or for any other spatial (or non-spatial) measure of relevance.

INFERRING EFFECTIVENESS

Ideally effectiveness should be quantitatively assessed as described above. When assessing the effectiveness of a measure, those areas that have been quantitatively evaluated and shown to have produced conservation benefits through their management actions should have the lowest uncertainty that their evaluation is correct, as these analyses can attribute the cause of the change to the management action. Such evaluations are generally available in Canada for fisheries closures relative to fish populations and sometimes other biodiversity features (O'Boyle, 2011), but are less common for areas closed to achieve biodiversity objectives (Syms and Carr, 2001; O'Boyle, 2011). For the latter, effectiveness may have to be evaluated using indirect measures. Alternatively, areas where the conservation objective has been met, even if the result cannot be unequivocally assigned to the management action, have a greater probability of being sites where effective measures were applied than are areas where no effect has been observed. The key point is that some type of assessment of effectiveness should be made.

However, often the data for quantitative evaluations of effectiveness will not be available and evaluation of conservation benefits must make the most of what information is obtainable. This will often be the case for conservation areas and MPAs that are newly created, and the future trajectories of the biodiversity must be inferred or modeled. In other cases a set of spatial measures may have been in place for some time, but only the present state of the biodiversity components of interest can be quantified, i.e., there are insufficient historical data from earlier states of the area, and adjacent areas may serve as questionable "controls" because their historical trajectories are no better known. Also, some areas may have been considered natural or pristine from the outset and spatial closures and associated management plans were put in place as preventative measures against future threats. In such cases, "effectiveness" may require some to extensive inference from experience elsewhere, to help interpret whatever site specific data may be available. Sometimes biological and ecological mechanisms, similar to the management ones proposed by the CCEA have been suggested, but it is noted that these suffer the same criticism of assumption of effectiveness.

Fortunately there have been a number of reviews of factors that have contributed to the effectiveness (or lack of effectiveness) of MPAs and other spatial measures, and those reviews provide some guidance to help make scientifically sound inferences (with full acknowledgement of uncertainties). Here, the focus is on factors that have underpinnings in ecology and on reviews and research articles that examine either conservation benefits or MPA effectiveness with respect to those factors. In particular, 14 review articles (Table 9) were considered in preparing the following list of attributes. These were augmented by other reviews and primary research publications for specific factors.

SIZE

Evidence - Size is discussed in most of the reviewed papers. To be effective, the literature suggests that the size of an area size should at least be as large as the average larval dispersal distance of targeted species and encompass the adult home range or neighbourhood size (Burt et al., 2014). However, size does not always guarantee protection (Halpern, 2003; Agardy et al., 2011; Al-Abdulrazzak and Trombulak, 2012; De Santo, 2013). Still, larger reserves are more likely to contain rare species (Halpern, 2003) and in a global review of 87 MPAs, large MPA size (> 100 km^2) was found to contribute to conservation effectiveness (Edgar et al., 2014) when combined with other factors.

Special Considerations and Mechanisms - Ecological mechanisms that govern diversity have been shown to be scale- and context-dependent (Cusson et al., 2015), making it impossible to standardize size as a screening tool without reference to the target species. The FAO (MPA design and implementation considerations) similarly concludes that the amount of area that should be protected "depends on the objectives of the MPAs, the nature of protection that applies outside of MPAs (i.e., other fishery management regulations), and the biology of the species that are to be protected".

Nevertheless, Balmford et al. (2002) proposed a simple indicator for conservation benefit based on size. Their premise was that many of the evolutionary and ecological processes that underpin biological diversity can be maintained only in large areas of habitat, and therefore, one measure of potential conservation benefit is the total area conserved. The CCEA guidelines also mention the issue of size and connectivity with respect to achievement of biodiversity conservation. McLeod et al. (2009) recommended, from a tropical reef perspective, that "MPAs should be a minimum of 10–20 km in diameter to be large enough to protect the full range of marine habitat types and the ecological processes on which they depend (Palumbi et al., 1997; Friedlander et al., 2003; Palumbi, 2004; Fernandes et al., 2005; Mora et al., 2006; Green et al., 2007), and to accommodate self-seeding by short distance dispersers". Laurel and Bradbury (2006) found that with each degree of increase in latitude, there was on average an 8% increase in dispersal potential and decrease in population substructure. Therefore MPAs placed in high latitudes may need to be much larger in size in order to be effective.

Overall Conclusion - Size is a relevant consideration in effectiveness, but not an absolute screening criterion for "effective" or "not effective". If biodiversity components of specific relevance are specified for the area, then consideration of the life history of the species, and the aspects of the life history intended to benefit from the area (e.g., spawning closures or nursery area, habitat for a protected species) can determine a minimum size.

SPATIAL RELATIONSHIPS (CONNECTIVITY AND FRAGMENTATION)

Evidence - The scientific literature shows that closed areas that are large and functionally connected to other reserves are thought to confer more effective protection of biodiversity than small, isolated reserves (Anon, 2008). Evidence based on empirical data and simulation models emphasizes the importance of connectivity between MPAs (Botsford et al., 2009; White et al., 2010; Grüss et al., 2011). Larval dispersal distance and mobility for the key species is used to identify spacing between closed areas. In particular a distinction can be drawn between sessile species and those with short distance dispersal, and mobile species and those with long-distance dispersal, with the former populations able to persist in smaller areas (4- 6 km; Shanks et al., 2003) and the later in larger areas (10-100 km minimum; Botsford et al., 2009; Gaines et al., 2010; Pujolar et al., 2013). In contrast, Edgar et al. (2014) provide evidence that closed areas that were isolated (in their review these were coral reefs surrounded by deep water or sand) were more effective than those that were not.

Special Considerations and Mechanisms - Connectivity is the natural linkage between marine habitats (Roberts et al., 2003), which occurs via larval dispersal and the movements of adults and juveniles. Although Roberts et al. (2003) were addressing horizontal connectivity, connectivity also occurs vertically, both as an avenue to expose organisms to the mechanisms for horizontal movements, and more locally within a water column, coupling pelagic, demersal and benthic communities. Connectivity is an important part of ensuring larval exchange and the replenishment of biodiversity in areas damaged by natural or human-related agents. Connectivity is a property that influences the structure, diversity, productivity, dynamics, and resilience of marine ecosystems by providing feedbacks and subsidies of organisms, nutrients, and energy across ecosystem boundaries. Connectivity is perhaps most evident in spatial fluxes, as most marine ecosystems maintain strong connections with adjacent and distant ecosystems through the flux of larval, juvenile and adult organisms across ecosystem boundaries (Shanks et al., 2003; Shanks, 2009). Organisms that actively move across the landscape, such as marine mammals, fish, turtles, seabirds etc., and connect habitats in space and time ('mobile link organisms': Lundberg and Moberg, 2003) may contribute strongly to marine ecosystem resilience (Brock et al., 2012). Mobile link organisms may be essential components in the dynamics of ecosystem development and resilience because they provide a buffering capacity between sites and can be sources for recolonization after disturbance. The planktonic larval durations (PLD) of marine fishes and invertebrates represent an index of potential connectivity that varies on small scales and across biogeographic regions. The general movement ranges and common depth occurrence for adult fish and invertebrate species and their pelagic larval duration off British Columbia have been reviewed by Burt et al. (2014) and can provide some guidance on this measure. Larval trajectories using Lagrangian simulations based on oceanographic models and supported by genetic evidence have been used to explore the patterns of connectivity between MPAs and neighbouring non-protected areas and to determine the scale at which the benefits of MPAs are expected (Pujolar et al., 2013). WebDrogue is a drift trajectory program (Hannah et al., 2000), which computes drift trajectories using circulation derived from the tides, the seasonal mean circulation, wind-driven circulation, and a surface-wind drift. The model allows for forward projection and hind-casting of particles at different seasons and water depths and is available for most areas on the east coast of Canada. Such models can be used to evaluate the connectivity pathways for closed areas.

Consideration by Other Jurisdictions - The United States National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) has no formal definition of net conservation benefit in this context, but does claim that such benefits may result from "reducing fragmentation and increasing the connectivity of habitats, maintaining or increasing populations, insuring against catastrophic events, enhancing and restoring habitats, buffering protected areas, and creating areas for testing and implementing new conservation strategies" (NOAA, 1999) - all amenable to monitoring. Interestingly, size is not a direct attribute.

The IUCN (2008) recommends that the spacing between individual MPA sites should range from 10 - 100 km (depending on the habitat type and region).

Overall Conclusion - Connectivity is an important part of ensuring larval exchange and the replenishment of biodiversity in areas damaged by natural or human-related agents. Closed areas where the connectivity of the system was considered in the design and placement, i.e., are part of a network of MPAs, are a relevant consideration in evaluating effectiveness.

BETA-DIVERSITY

Evidence - High beta-diversity (or habitat heterogeneity) appears to enhance ecosystem resilience of desirable ecosystem states in the face of change (Peterson et al., 1998; Elmqvist et al., 2003). Different marine habitat types encompass distinct species assemblages; therefore, MPAs which include a variety of habitats will have a greater likelihood of including more species and hence have a higher species and beta-diversity (Carr et al., 2003; Friedlander et al., 2003; Lubchenco et al., 2003; Astorga et al., 2014).

Special Considerations and Mechanisms - High beta-diversity indicates large spatial heterogeneity in species distribution, reflecting fragmented populations and, possibly, low connectivity of local species assemblages within the regional species pool. Beta-diversity is determined through a complex array of processes relating to the interaction of species traits and characteristics of the physical landscape over time. Geographic variation in beta-diversity reflects past and present differences in environment, ecological interactions, and biogeographic history, including barriers to dispersal. As beta-diversity quantifies the turnover in species across space, it has important applications to the scaling of diversity, the delineation of biotic regions and conservation planning (McKnight et al., 2007; Awiti, 2011). Winberg and Davis (2014) have shown that MPAs significantly affected non-target fauna and produced shifts in beta-diversity. Beta-diversity will be positively related to substrate heterogeneity (Astorga et al., 2014) and depth (Lorance et al., 2002), and habitat heterogeneity is one of the most commonly identified habitat characteristics considered critical for maintaining marine ecosystem functioning (Foley et al., 2010). Habitat heterogeneity is created and maintained by interrelated geologic, biogenic and disturbance factors at multiple scales, from millimeters to kilometers. In contrast, low beta-diversity is indicative of more homogeneous patterns of species distribution, possibly reflecting high connectivity, and more uniform substrates.

Overall Conclusion - Beta-diversity is a relevant consideration in effectiveness. If biodiversity conservation is specified for the area, then the depth gradient and substrate heterogeneity, as surrogates for beta-diversity, should be considered when inferring effectiveness, especially for assessing co-benefits.

LENGTH OF TIME UNDER PROTECTIVE MEASURES

Evidence - Edgar et al. (2014) in a global review of 87 MPAs, found that closures that had been in place for more than 10 years showed conservation effectiveness in combination with other factors. Selig and Bruno (2010) also found that the benefits of MPAs appear to increase with the number of years since MPA establishment in coral reef systems. Starr et al. (2004) found similar results in temperate kelp forest systems with effects being greater in older closed areas than in newer ones. Presumably the degree to which the age of the closed areas is a relevant factor in effectiveness depends on the state of the system at the time of closure. Ecological changes associated with Kenya's fisheries closures in tropical reef lagoon ecosystems were examined for 5 fisheries closures that ranged in age since closure from 5 to 41 yr. Recovery, processes were generally slow and functional group recovery was not fully complete by ~35 yr of closure (McClanahan, 2014).

Special Considerations and Mechanisms - Disturbed areas follow recovery trajectories that may depend on successional processes to occur. Recovery trajectories may not always be predictable. McClanahan (2014) found that time since closure was a strong predictor ($R^2 > 0.50$) for benthic macrophytes (seagrass and red coralline algae) on a 20 to 30 yr time scale, but less so for other trophic levels. Consequently, management measures for a conservation area may be appropriate but not effective at the time of evaluation due to the successional state of the ecosystem following recovery. Disturbances can also occur due to environmental changes. Jameson et al. (2002) concluded, using a tropical reef example, that MPAs are unlikely to be effective if they are located in areas that are subject to extreme large scale events (e.g., hurricanes, oil spills, tropical cyclones) which can degrade the environment and compromise protection. Such events would also reset recovery trajectories (Beeden et al., 2015) and could mask any effects of management.

Overall Conclusion - Ecological processes in closed areas are likely to require decades to recover and permanent and older closures are therefore more likely to demonstrate effectiveness at achieving conservation benefits.

SUSTAINABLE MANAGEMENT STRATEGIES IMPLEMENTED OUTSIDE OF CLOSED AREAS

Evidence - Hilborn et al. (2006) show that the effectiveness of MPAs can be diminished by fishing adjacent to closed areas, in some cases even if that fishing is managed sustainably.

Special Considerations and Mechanisms - Oceanographic and anthropogenic activities occurring outside of the closed area can affect ecosystems, communities, and species within. Management objectives for closed areas should ideally take into account the ability of the closure to mitigate threats that exist beyond their borders, in order to be effective for wide-ranging species or large-scale processes (Ban et al., 2010). This is particularly relevant to water quality issues in coastal closed areas (McLeod et al., 2009). Further, conservation of highly mobile exploitable species will require sustainable management strategies to be implemented outside of the closed area boundaries (Burt et al., 2014). This will be an important consideration if the full potential benefits of networks of closed areas are desired (see the discussion of "Connectivity"). If the benefits arising through connectivity of areas require animals to move between or in and out of closed areas where they are protected, the benefits will require activities to be sustainably managed outside the closed areas.

Overall Conclusion - Closed areas where the objective is to protect highly mobile species will be more effective if management strategies are in place outside of the closed areas to protect the species when they are not resident in the closed area and may be ineffective for mobile species if threats are poorly managed outside the closed area.

LOCATION IN RELATION TO PREFERRED HABITAT

Evidence - Models show that protected areas located in feeding grounds may affect size structure in certain fish populations, while protection in spawning grounds may enhance larval production (Dunlop et al., 2009). Field studies that would allow confirmation of these model results are needed to support these theoretical (Law, 2007) and modeled (Dunlop et al., 2009) conclusions. The presence of structure forming benthic species (e.g., corals, sponges, etc.) or features (reefs) are associated with increased biodiversity at local and regional scales (Buhl-Mortensen et al., 2010).

Special Considerations and Mechanisms - Location in relation to preferred habitat is an important consideration because large aggregations of species may occur in or around a specific habitat or oceanographic features. If MPAs are created at random, or placement is strongly influenced by social and economic considerations, and preferred habitat is not taken as a priority, then benefits may be minimal. Dunlop et al. (2009) determined that reserves located in feeding habitats could potentially reduce evolutionary-selected pressures on species and therefore preserve evolutionary traits (e.g. age and size at maturation).

Overall Conclusion - Closed areas where the objective is to protect specific species will be more effective if the habitat preferences of the species are included in selecting the areas to be closed. These preferences may be different for different life history stages of a species. So the selection of spatial measures needs to address the threats to the relevant life history stage(s). If areas are closed to protect "biodiversity" in a general way, then the considerations of beta-diversity, including the presence of structure forming species, are important.

PARTIAL VERSUS FULL PROTECTION

Evidence - Sciberras et al. (2013) synthesized the results of 40 empirical studies of 63 MPAs that compared partially protected areas, no-take marine reserves and open access areas, to assess the potential benefits of different levels of protection for fish and invertebrate populations. They applied a rigorous systematic review to ensure that the data were appropriate for their analyses. They found that no-take reserves provided some benefits over less protected areas, but that significant ecological effects of partially protected areas relative to open access areas were achieved. Lester and Halpern (2008) also showed that partially protected areas may produce conservation benefits but found greater differences between no-take areas and partially protected areas than reported by Sciberras et al. (2013) with respect to overall benefit and density of organisms. Bennett and Dearden (2014) promote no take areas or the creation of multiple use MPAs with a no-take zone in their framework based on the work of Lester and Halpern (2008) and Lester et al. (2009).

Special Considerations and Mechanisms - Protected areas encompass a range of protection levels, from fully protected no-take areas to the restriction of only particular activities, gear types, user groups, target species or extraction periods. Shellfish contamination closures (SCCs) and “Prohibition for Contaminated Fisheries” regulations would appear to be unlikely candidates for effective closures, but in the case of SCCs the major threat to biodiversity may be through the harvesting that is prohibited, thereby creating conservation co-benefits. Further, such areas are often stable in their boundaries with respect to location. Areas closed for contaminated fisheries should be evaluated for the stability of the locations affected by the closures and for the expected duration of the closures. Areas under review should then be evaluated for effectiveness using all available data. When it is necessary to infer effectiveness from the properties of the closed area and its management regime, an important consideration is to evaluate whether events occurring outside of the closed area could negatively influence effectiveness.

Overall Conclusion - Areas which receive only partial protection may still be effective at producing conservation benefits, if the measures in place have been shown to effectively reduce threat(s) and show differences in biodiversity compared to areas that do not receive the partial protection.

DENSITY, SIZE AND AGE STRUCTURE OF KEY SPECIES

Evidence - Areas closed to fishing may exhibit a more natural species composition, age structure, spawning potential and genetic variability of stock (Bohnsack and Ault, 1996; McClanahan et al., 2006). In a review of the literature, Halpern (2003) has shown that closing areas leads to increases in density, biomass, individual size, and diversity in all functional groups. This effect was especially pronounced for sessile organisms where density was between 20 – 30% higher relative to unprotected areas. In a meta-analysis of data collected from 19 marine reserves, Côté et al. (2001) found a significant increase (11%) in fish species number inside marine reserves compared to adjacent areas. Fish abundance was also higher (28%) inside reserves for commercial fish species, but there was no overall change in fish abundance when all species were considered.

Special Considerations and Mechanisms - Increase in density may result in increased competition, predation rates, and movement rates within the closed area (St. Mary et al., 2000). These indirect responses of populations to changes in density may alter the effectiveness of a closed area (Syms and Carr, 2001). Recent theoretical (e.g., Jørgensen et al. 2009) and empirical studies (e.g., Mollet et al. 2007) have provided compelling evidence that selective fishing can cause earlier ages and smaller sizes at maturation that can be reversed through spatial closures (Dunlop et al., 2009) albeit over long periods of time.

Consideration by Other Jurisdictions - The IUCN (Pomeroy et al., 2004) considers that an effectively managed MPA is one that contains populations of focal species whose individuals are adequately distributed from juvenile to adult size classes so as to allow them to replenish themselves and be viable (i.e. persist in the area through time). This condition is more readily met for largely sedentary species than for highly mobile species, especially if habitat preferences change with age or size. Species abundance is thought to reflect the status of a species' population within a specific location and is one of the most widely used biological ‘success’ measures of management effectiveness (Pomeroy et al., 2004).

Overall Conclusion - Areas which show an increase in density, biomass, individual size and the presence of longer lived individuals compared with areas outside of the closure are likely the product of effective protection measures.

OTHER FACTORS

In reviewing the above (Table 9), other considerations primarily related to the governance and management of the closed areas were reported by one or more authors. These were:

1. biodiversity objectives stated in the goals;
2. the naturalness of the area;
3. the legal or social authority that created the MPA;
4. the types of enforcement/surveillance;
5. whether the closed area was created through bottom-up or top-down discussions; and
6. whether monitoring and evaluations took place and evoked adaptive measures.

These are just some of the many socio-economic and governance properties that are discussed in the literature in relation to effectiveness of a closed area. The conclusions drawn for these other factors in considered in the review articles are available in Table 10a, b. Of these, it has already been discussed the implications of having the biodiversity objectives stated in the goals of the closed area with respect to effectiveness. The other measures ultimately relate to how effective the measures are in controlling human activities. Inclusiveness in formulating the management plan is more likely to lead to buy-in for following the regulations; however management measures do not necessarily result in an effective closed area as has been demonstrated.

CONCLUSIONS

Based on the summaries of what the several reviews of closed areas have concluded (Tables 9 and 10), an empirically based set of factors against which to evaluate the variety of closed areas in Canada's marine waters is presented. None of the reviews concluded that any individual factor was either necessary or sufficient to ensure conservation of biodiversity, but each could contribute to conservation of some or many aspects of biodiversity if applied in an appropriate manner. This leads to the conclusion that scientifically sound decisions about what to include as areas where "other effective area-based conservation measures" are in place will have to be done on a case by case basis. Different types of areas where spatial measures are in place will need to be evaluated for whether they meet the definition of a protected area, and for the individual cases within a type of "closed area" to evaluate whether the conservation area is or is likely to be effective at conserving biodiversity. The decisions can be informed by both empirical evidence of "conservation benefits" when monitoring or sampling data from the closed areas are compared to data from appropriate adjacent or otherwise similar areas that are not "closed", and inferential evidence from the presence and nature of the factors discussed above.

In going forward with evaluations of effectiveness, assessors should include area-based measures that can be shown to provide conservation benefit or are highly likely to provide conservation benefit given their intent, size, connectivity, beta-diversity, longevity, population demographics, location with respect to preferred habitat, degree of protection and influence of human activities and the environment both inside the closed area and in the area of influence surrounding it. Areas may provide conservation benefit even if associated management objectives are not related to conservation of biodiversity. All areas have the potential to effectively conserve biodiversity whether they are closed for all or part of the year (see "Partial versus Full Protection").

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TABLES

Table 1. Aichi Biodiversity Targets.

Reference	Target
Goal A	***Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society***
Target 1	By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.
Target 2	By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems.
Target 3	By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio economic conditions.
Target 4	By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.
Goal B	***Reduce the direct pressures on biodiversity and promote sustainable use***
Target 5	By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.
Target 6	By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.
Target 7	By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.
Target 8	By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity.

Reference	Target
Target 9	By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment.
Target 10	By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.
Goal C	***To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity***
Target 11	By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.
Target 12	By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.
Target 13	By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity.
Goal D	***Enhance the benefits to all from biodiversity and ecosystem services***
Target 14	By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable
Target 15	By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.
Target 16	By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.
Goal E	***Enhance implementation through participatory planning, knowledge management and capacity building***
Target 17	By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.

Reference	Target
Target 18	By 2020, the traditional knowledge, innovations and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity, and their customary use of biological resources, are respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention with the full and effective participation of indigenous and local communities, at all relevant levels.
Target 19	By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied.
Target 20	By 2020, at the latest, the mobilization of financial resources for effectively implementing the Strategic Plan for Biodiversity 2011-2020 from all sources, and in accordance with the consolidated and agreed process in the Strategy for Resource Mobilization, should increase substantially from the current levels. This target will be subject to changes contingent to resource needs assessments to be developed and reported by Parties.

Table 2. Canada's National Biodiversity Targets for Beyond 2010 extracted from [Canada's 5th National Report to the Convention on Biological Diversity, March 2014 [PDF]].

Reference	Target	Related Aichi Target(s)
Goal A	***By 2020, Canada's lands and waters are planned and managed using an ecosystem approach to support biodiversity conservation outcomes at local, regional and national scales.***	18
Target 1	By 2020, at least 17 percent of terrestrial areas and inland water, and 10 percent of coastal and marine areas, are conserved through networks of protected areas and other effective area-based conservation measures.	11
Target 2	By 2020, species that are secure remain secure, and populations of species at risk listed under federal law exhibit trends that are consistent with recovery strategies and management plans.	12
Target 3	By 2020, Canada's wetlands are conserved or enhanced to sustain their ecosystem services through retention, restoration and management activities.	4, 5, 14, 15
Target 4	By 2020, biodiversity considerations are integrated into municipal planning and activities of major municipalities across Canada.	2
Target 5	By 2020, the ability of Canadian ecological systems to adapt to climate change is better understood, and priority adaptation measures are underway.	19
Goal B	***By 2020, direct and indirect pressures as well as cumulative effects on biodiversity are reduced, and production and consumption of Canada's biological resources are more sustainable.***	
Target 6	By 2020, continued progress is made on the sustainable management of Canada's forests.	4, 5, 7
Target 7	By 2020, agricultural working landscapes provide a stable or improved level of biodiversity and habitat capacity.	5, 7
Target 8	By 2020, all aquaculture in Canada is managed under a science-based regime that promotes the sustainable use of aquatic resources (including marine, freshwater and land based) in ways that conserve biodiversity.	4, 7

Reference	Target	Related Aichi Target(s)
Target 9	By 2020, all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem-based approaches.	6
Target 10	By 2020, pollution levels in Canadian waters, including pollution from excess nutrients, are reduced or maintained at levels that support healthy aquatic ecosystems.	8
Target 11	By 2020, pathways of invasive alien species introductions are identified, and risk-based intervention or management plans are in place for priority pathways and species.	9
Target 12	By 2020, customary use by Aboriginal peoples of biological resources is maintained, compatible with their conservation and sustainable use.	18
Target 13	By 2020, innovative mechanisms for fostering the conservation and sustainable use of biodiversity are developed and applied.	3, 4
Goal C	***By 2020, Canadians have adequate and relevant information about biodiversity and ecosystem services to support conservation planning and decision-making.***	
Target 14	By 2020, the science base for biodiversity is enhanced and knowledge of biodiversity is better integrated and more accessible.	19
Target 15	By 2020, Aboriginal traditional knowledge is respected, promoted and, where made available by Aboriginal peoples, regularly, meaningfully and effectively informing biodiversity conservation and management decision-making.	18
Target 16	By 2020, Canada has a comprehensive inventory of protected spaces that includes private conservation areas.	11, 19
Target 17	By 2020, measures of natural capital related to biodiversity and ecosystem services are developed on a national scale, and progress is made in integrating them into Canada's national statistical system.	1
Goal D	***By 2020, Canadians are informed about the value of nature and more actively engaged in its stewardship.***	
Target 18	By 2020, biodiversity is integrated into the elementary and secondary school curricula.	1
Target 19	By 2020, more Canadians get out into nature and participate in biodiversity conservation activities.	1, 4

Table 3. Technical Rationale for Aichi Biodiversity Target 11 (COP/10/INF/12/Rev.1)

Quick Guides for the Aichi Biodiversity Targets

Subject	Description
Strategic Goal C:	To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity
Target 11:	By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape.
Technical rationale:	Well governed and effectively managed protected areas are a proven method for safeguarding both habitats and populations of species and for delivering important ecosystem services. Currently, some 13 per cent of terrestrial areas and 5 per cent of coastal areas are protected, while very little of the open oceans are protected. The current target of 10 per cent protection for each ecological region has been achieved in approximately 55 per cent of all terrestrial eco-regions. Therefore reaching this target implies a modest increase in terrestrial protected areas globally, with an increased focus on representivity and management effectiveness. It further implies that major efforts to expand marine protected areas would be required. A focus on representivity is crucial as current protected area networks have gaps, and some fail to offer adequate protection to many species and ecosystems. These gaps include many sites of high biodiversity value such as Alliance for Zero Extinction sites and Important Bird Areas. Particular emphasis is needed to protect critical ecosystems such as tropical coral reefs, sea-grass beds, deepwater cold coral reefs, seamounts, tropical forests, peat lands, freshwater ecosystems and coastal wetlands.
Implementation:	Protected areas should be integrated into the wider land- and seascape, and relevant sectors, bearing in mind the importance of complementarity and spatial configuration. In doing so, the Ecosystem Approach should be applied taking into account ecological connectivity and the concept of ecological networks, including connectivity for migratory species (through, for example, “fly-ways” for migratory birds). Protected areas should also be established and managed in close collaboration with, and through equitable processes that recognize and respect the rights of indigenous and local communities, and vulnerable populations. These communities should be fully engaged in governing and managing protected areas according to their rights, knowledge, capacities and institutions, should equitably share in the benefits arising from protected areas and should not bear inequitable costs. IUCN’S Guidelines for applying protected area management categories recognizes four broad types of governance of protected areas, any of which can be associated with any management objective. These categories include governance by government, shared governance, private governance, and governance by indigenous peoples and local communities. These cut across all categories of protected areas. Other effective area based conservation measures may also include restrictions on activities that impact on

Subject	Description
	biodiversity, which would allow for the safeguarding of sites in areas beyond national jurisdiction in a manner consistent with the jurisdictional scope of the Convention as contained in Article 4. Work towards this target could also be linked to the more specific targets under the programme of work on protected areas and the Global Strategy for Plant Conservation. The World Parks Congress is a further resource which can be drawn upon when taking actions towards this target. Protected areas could be complemented by limits to processes and activities harmful to biodiversity that are under the jurisdiction or control of Parties, including in areas beyond national jurisdiction, while ensuring that such limits do not infringe on the rights of indigenous or local communities, or vulnerable populations.
Indicator and baseline information:	Relevant indicators to measure progress towards this target are the coverage of sites of significance for biodiversity covered by protected areas and the connectivity/fragmentation of ecosystems. Other possible indicators include the trends in extent of selected biomes, ecosystems and habitats, the Marine Trophic Index, the overlay of protected areas with ecoregions, the governance and management effectiveness of protected areas, trends in the extent of selected biomes, ecosystems and habitats, and water quality in aquatic ecosystems. Strong baseline information, from sources such as the World Database of Protected Areas, Alliance for Zero Extinction, Integrated Biodiversity Assessment Tool, IUCN Red List of Threatened Species and the IUCN World Commission on Protected Areas, already exists for many of these indicators.

Table 4. Indicators for Goal A, Target 1 of the [2020 Biodiversity Goals and Targets for Canada](#).

Biodiversity Goal	Description	Target	Indicators
Goal A	By 2020, Canada's lands and waters are planned and managed using an ecosystem approach to support biodiversity conservation outcomes at local, regional and national scales.	By 2020, at least 17 percent of terrestrial areas and inland water, and 10 percent of coastal and marine areas, are conserved through networks of protected areas and other effective area-based conservation measures.	• Percentage of total terrestrial territory (including inland water) conserved in protected areas and other effective area-based conservation measures. • Percentage of total coastal and marine territory conserved in marine protected areas and other effective area-based conservation measures.

Table 5. Comparison of IUCN Protected Area Categories, Canadian Council on Ecological Areas (CCEA) Descriptors and DFO Area-Based Management Categories.

IUCN Protected Area Category	Distinguishing Features of IUCN Category (Dudley, 2008; IUCN, 2014)	CCEA Protected Area Category	CCEA (Canadian Interpretation) Description (Anon., 2008)	CCEA Size Guidelines (Anon., 2008)	DFO Area-Based Management Category/ Description
Ia) Strict Nature Reserve	a. Have a largely complete set of expected native species in ecologically significant densities or be capable of returning them to such densities through natural processes or time-limited interventions; b. Have a full set of expected native ecosystems, largely intact with intact ecological processes, or processes capable of being restored with minimal management intervention; c. Be free of significant direct intervention by modern humans that would compromise the specified conservation objectives for the area, which usually implies limiting access by people and excluding settlement; d. Not require substantial and on-going intervention to achieve its conservation objectives; e. Be surrounded when feasible by land uses that contribute to the achievement of the area's specified conservation objectives; f. Be suitable as a baseline monitoring site for monitoring the relative impact of human activities; g. Be managed for relatively low visitation by humans; h. Be capable of being managed to ensure minimal disturbance (especially relevant to marine environments).	Ia	a. Category Ia applies to areas managed for strict nature protection; b. All activities should be consistent with the objectives of management and guidance for selection: there should be no non-conforming uses.	For continental ecosystems, the best advice is that extremely large areas are required to conserve all species and processes. In continental North America the estimate is 500,000 ha. These estimates follow the predictions of island biogeography theory. Note that areas are much smaller for island ecosystems. The general rule is that bigger areas will protect more biodiversity than smaller areas. See also Category III	
Ib) Wilderness Area	a. Be free of modern infrastructure, development and industrial extractive activity, including but not limited to roads, pipelines, power lines, cellphone towers, oil and gas platforms, offshore liquefied natural gas terminals, other permanent structures, mining, hydropower development, oil and gas extraction, agriculture including intensive livestock grazing, commercial fishing, low-flying aircraft etc., preferably with highly restricted or no motorized access; b. Be characterized by a high degree of intactness: containing a large percentage of the original extent of the ecosystem, complete or near-complete native	Ib	a. Category Ib applies to areas managed for strict nature protection. b. All activities should be consistent with the objectives of management and guidance for selection: there should be no non-conforming uses.	See Category Ia and Category III	

IUCN Protected Area Category	Distinguishing Features of IUCN Category (Dudley, 2008; IUCN, 2014)	CCEA Protected Area Category	CCEA (Canadian Interpretation) Description (Anon., 2008)	CCEA Size Guidelines (Anon., 2008)	DFO Area-Based Management Category/ Description
	faunal and floral assemblages, retaining intact predator-prey systems, and including large mammals; c. Be of sufficient size to protect biodiversity; to maintain ecological processes and ecosystem services; to maintain ecological refugia; to buffer against the impacts of climate change; and to maintain evolutionary processes; d. Offer outstanding opportunities for solitude, enjoyed once the area has been reached, by simple, quiet and non-intrusive means of travel (i.e., non-motorized or highly regulated motorized access where strictly necessary and consistent with the biological objectives listed above); e. Be free of inappropriate or excessive human use or presence, which will decrease wilderness values and ultimately prevent an area from meeting the biological and cultural criteria listed above. However, human presence should not be the determining factor in deciding whether to establish a Category Ib area. The key objectives are biological intactness and the absence of permanent infrastructure, extractive industries, agriculture, motorized use, and other indicators of modern or lasting technology.				
II) National Park	a. The area should contain representative examples of major natural regions, and biological and environmental features or scenery, where native plant and animal species, habitats and geodiversity sites are of special spiritual, scientific, educational, recreational or tourist significance; b. The area should be of sufficient size and ecological quality so as to maintain ecological functions and processes that will allow the native species and communities to persist for the long term with minimal management intervention; c. The composition, structure and function of biodiversity should be to a great degree in a “natural” state or have the potential to be restored to such a state, with relatively low risk of successful invasions by non-native species.	II		See Category Ia	Some MPAs may fit in this category.

IUCN Protected Area Category	Distinguishing Features of IUCN Category (Dudley, 2008; IUCN, 2014)	CCEA Protected Area Category	CCEA (Canadian Interpretation) Description (Anon., 2008)	CCEA Size Guidelines (Anon., 2008)	DFO Area-Based Management Category/ Description
III) Natural Monument or Feature	a. Natural geological and geomorphological features: such as waterfalls, cliffs, craters, caves, fossil beds, sand dunes, rock forms, valleys and marine features such as sea mounts or coral formations; b. Culturally-influenced natural features: such as cave dwellings and ancient tracks; c. Natural-cultural sites: such as the many forms of sacred natural sites (sacred groves, springs, waterfalls, mountains, sea coves etc.) of importance to one or more faith groups; d. Cultural sites with associated ecology: where protection of a cultural site also protects significant and important biodiversity, such as archaeological/historical sites that are inextricably linked to a natural area.	III	a. Commercial extraction of any kind and energy development is not acceptable in Category III. (In some cases, these activities may be grandfathered until pre-existing plans or agreements expire. Historical water control structures that have created modified natural habitats may also be grandfathered.) Any other commercial activity that may alter the habitat or ecological integrity of the protected area, including commercial harvesting at a level or in a manner that may compromise the objectives of management of the protected area, is not acceptable in Category III.	There are many tools available to calculate the area required to protect viable populations or communities. The size required to ensure long-term protection will vary widely. If the objective is to protect a particular plant species, this may be done in an area of a few hectares. If the goal is to protect a viable population of a large predator, the area may be as high as one million hectares.	Special importance for cultural heritage: an area where use of the marine environment and living marine resources are or have been of particular cultural or historical importance (e.g., for the support of traditional subsistence activities for food, social or ceremonial use; significant historical and archaeological sites, heritage wrecks) (Government of Canada, 2011)
IV) Habitat/ Species Manageme nt Area	a. Protection of particular species: to protect particular target species, which will usually be under threat (e.g., one of the last remaining populations); b. Protection of habitats: to maintain or restore habitats, which will often be fragments of ecosystems; c. Active management to maintain target species: to maintain viable populations of particular species, which might include for example artificial habitat creation or maintenance (such as artificial reef creation), supplementary feeding or other active management systems; d. Active management of natural or semi-natural ecosystems: to maintain natural or semi-natural habitats that are either too small or too profoundly altered to be self-sustaining, e.g., if natural herbivores are absent they may need to be replaced by livestock	IV	a. The primary focus of this category is to ensure the maintenance of native species, their habitats, and/or biotic communities. Active management may not be required. In other circumstances active management may be required to meet biological diversity objectives; b. Areas requiring intensive active management to maintain their desired conditions belong here. Some of these areas may be managed to "enhance" habitat	See Category III	O'Boyle (2011): Groundfish Closures, US Gulf of Maine Area (17,131 km^2) Haddock Spawning Closure, Browns Bank (12,332 km^2) Haddock Nursery Closure, Emerald/Western Bank (12,776 km^2) Lobster Closure, Browns Bank

IUCN Protected Area Category	Distinguishing Features of IUCN Category (Dudley, 2008; IUCN, 2014)	CCEA Protected Area Category	CCEA (Canadian Interpretation) Description (Anon., 2008)	CCEA Size Guidelines (Anon., 2008)	DFO Area-Based Management Category/ Description
	or manual cutting; or if hydrology has been altered this may necessitate artificial drainage or irrigation; e. Active management of culturally-defined ecosystems: to maintain cultural management systems where these have a unique associated biodiversity. Continual intervention is needed because the ecosystem has been created or at least substantially modified by management. The primary aim of management is maintenance of associated biodiversity.		conditions for significant species or groups of species, and others may be managed to restore or maintain physical features of the environment or representative ecosystems; c. Commercial extraction of any kind and energy development is not acceptable in Category IV. (In some cases, these activities may be grandfathered until pre-existing plans or agreements expire. Historical water control structures that have created modified natural habitats may also be grandfathered.) Any other commercial activity that may alter the habitat or ecological integrity of the protected area, including commercial harvesting at a level or in a manner that may compromise the objectives of management of the protected area, is not acceptable in Category IV.		(6,554 km^2) Gully MPA, Scotian Shelf (2,364 km^2) Coral Conservation Areas, Scotian Shelf (439 km^2) Eastport Peninsula MPA, Newfoundland (2.1 km^2)
V) Protected Landscape/ Seascape	a. Landscape and/or coastal and island seascape of high and/or distinct scenic quality and with significant associated habitats, flora and fauna and associated cultural features; b. A balanced interaction between people and nature that has endured over time and still has integrity, or where there is reasonable hope of restoring that integrity; c. Unique or traditional land-use patterns, e.g., as evidenced in sustainable agricultural and forestry systems and human settlements that have evolved in balance with their landscape.	V	a. Exploration and commercial extraction would be acceptable in Category V only where the nature and extent of the proposed activities is compatible with the objectives of management.	In general, ecosystems with sustainable use should be larger than unexploited ecosystems to protect the same species.	

IUCN Protected Area Category	Distinguishing Features of IUCN Category (Dudley, 2008; IUCN, 2014)	CCEA Protected Area Category	CCEA (Canadian Interpretation) Description (Anon., 2008)	CCEA Size Guidelines (Anon., 2008)	DFO Area-Based Management Category/ Description
VI) Protected area with sustainable use of natural resources	a. Category VI protected areas, uniquely amongst the IUCN categories system, have the sustainable use of natural resources as a *means* to achieve nature conservation, together and in synergy with other actions more common to the other categories, such as protection; b. Category VI protected areas aim to conserve ecosystems and habitats, together with associated cultural values and natural resource management systems. Therefore, this category of protected areas tends to be relatively large (although this is not obligatory); c. The category is not designed to accommodate large-scale industrial harvest; d. In general, IUCN recommends that a proportion of the area is retained in a natural condition,7 which in some cases might imply its definition as a no-take management zone. Some countries have set this as two-thirds; IUCN recommends that decisions need to be made at a national level and sometimes even at the level of individual protected areas.	VI	a. Exploration and commercial extraction would be acceptable in Category VI only where the nature and extent of the proposed activities is compatible with the objectives of management; b. The protection and maintenance of biological diversity is the primary objective of Category VI. Sustainable use of resources is a secondary objective. Sites with sustainable use as the primary objective do not meet the criteria for Category VI; c. The “minimum 66 percent natural area” guideline should not be exchanged against modified areas. For example, forests cannot be harvested and then rezoned as natural landscapes and included in the 66-percent-natural portion of a reserve; d. Resource use in Category VI protected areas must be defined in the related protected area legislation, management plan or equivalent statement of management intent, which may be subject to a public consultation process.	See Category V	

Table 6. Canadian Council on Ecological Areas (CCEA) Draft Decision Screening Tool for "Other Effective Area-Based Conservation Measures" (Anon., 2013).

LEVEL OF AGREEMENT REGARDING POTENTIAL EFFECTIVENESS

<table>
<tr><td colspan="5">GREEN: Agreement on criteria that would help define "Target 11 other effective area-based conservation measures"</td></tr>
<tr><td colspan="5">YELLOW: Disagreement or hesitation on whether criteria defines a measure sufficiently effective to be "Target 11 OEAbCMs"</td></tr>
<tr><td colspan="5">RED: Agreement on criteria that define measures not sufficiently effective to be "Target 11 OEAbCMs"</td></tr>
<tr><td colspan="5">DEFINITIONS</td></tr>
<tr><td colspan="5">CONSERVATION: Conservation, in this context, refers to the in-situ maintenance of ecosystems and natural and semi-natural habitats and of viable populations of species in natural surroundings.</td></tr>
<tr><td colspan="5">BIODIVERSITY: Biodiversity, in this context, refers to the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes the diversity within species, between species, and of ecosystems.</td></tr>
<tr><td colspan="5">CONTEXT</td></tr>
<tr><td colspan="5">GOAL C: Improve the status of biodiversity by safeguarding ecosystems, species, and genetic diversity</td></tr>
<tr><td colspan="5">Primary measuring stick for assessing effectiveness: The long-term conservation of biodiversity
Left side - greater potential effectiveness; Right side - less potential effectiveness</td></tr>
<tr><td>Geographical Space</td><td>The geographical space is well-defined</td><td>The geographical space is not well-defined</td><td>The measure is not area-based</td><td></td></tr>
<tr><td>Primacy of Objective of Conservation of Nature</td><td>The conservation of biodiversity is the primary overriding objective</td><td>There are multiple objectives of equal priority in addition to the conservation of biodiversity</td><td>There are objectives that have primacy over the conservation of biodiversity, but conservation of biodiversity is still an objective</td><td>The conservation of biodiversity is not an objective</td></tr>
</table>

Scope of Conservation Objectives	The objectives are for the conservation of biodiversity as a whole, including ecosystems, species, and genetic diversity	The objectives are for the conservation of multiple elements of biodiversity, such as a species, group of species, habitat, or array of habitats, but not biodiversity as a whole	The objectives are for the conservation of one element of biodiversity, such as a species or habitat, but not biodiversity as a whole	The objectives are not for the conservation of any elements of biodiversity
Governing Authority	The governing authority(ies) has established the conservation of biodiversity as the sole mandate	The governing authority(ies) has multiple mandates, but the primary mandate is the conservation of biodiversity	The governing authority(ies) has multiple competing mandates, one of which is the conservation of biodiversity	The governing authority(ies) has no mandate for the conservation of biodiversity
Jurisdictional Authority/ Recognized	The governing authority has full jurisdiction to set permissible activities	The governing authority shares jurisdiction to set permissible activities by consensus	The governing authority has partial jurisdiction to set permissible activities	The governing authority has no jurisdiction to set permissible activities
Binding	The mechanism binds the governing authority and all others	The mechanism binds the governing authority but not all others	The mechanism does not bind the governing authority but binds all others	The mechanism is voluntary
Enforceability	The mechanism is highly enforceable	The mechanism is somewhat enforceable	The mechanism is poorly or not enforceable	
Legal or other effective means	The mechanism has the power and breadth to control all activities occurring within the area that could have impacts on biodiversity	The mechanism has the power and breadth to control some activities occurring within the area that could have impacts on biodiversity	The mechanism does not have the power and breadth to control activities occurring within the area that could have impacts on biodiversity	
Long-term	The mechanism is intended to be in effect in perpetuity	The mechanism is intended to be an interim step towards becoming in effect in perpetuity	The mechanism is intended to be in effect for the long term, but not in perpetuity	The mechanism is intended to be in effect for only a specific period of time, or indefinitely, but not in perpetuity
Dedicated	The mechanism can be reversed only with great difficulty	The mechanism can be reversed with moderate difficulty	The mechanism can be reversed without much difficulty	

Table 7. Canadian Council on Ecological Areas (CCEA) Additional Measures for Consideration in the Draft Decision Screening Tool for "Other Effective Area-Based Conservation Measures" (Anon., 2013).

Additional Considerations for Possible Inclusion in Screening Tool or in Additional Guidance							
Geographical Space / Adequacy	The space is sufficiently large and encompassing for its biodiversity objectives to be achieved	The space is not sufficiently large and encompassing that its biodiversity objectives can be achieved					
Conservation Targets	The space is located in an area that is of high value for biodiversity conservation	The space is not located in an area that is of high value for biodiversity conservation					
Conservation Outcomes	The outcomes are conservation of biodiversity as a whole, including ecosystems, species, and genetic diversity	The outcomes are the conservation of multiple elements of biodiversity, such as a species, group of species, habitat, or array of habitats, but not biodiversity as a whole	The outcomes are the conservation of one element of biodiversity, such as a species or habitat, but not biodiversity as a whole	The outcome is no conservation of any element of biodiversity			
Managed to Achieve	The area is effectively managed to achieve its conservation objectives (for example as evaluated using IUCN management effectiveness guidelines)	The area is somewhat effectively managed to achieve its conservation objectives (for example as evaluated using IUCN management effectiveness guidelines)	The area is not effectively managed to achieve its conservation objectives (for example as evaluated using IUCN management effectiveness guidelines)				
Legal or other effective means	The mechanism is one or more laws or regulations enforceable by federal, provincial, territorial, First Nations, or municipal government, which applies regardless of ownership of the area	The mechanism is ownership by a not-forprofit organization with a primary mandate for the long-term conservation of biodiversity, whose adherence to their by-laws is overseen by a federal, provincial, territorial, First Nations, or municipal Government	The mechanism is a legally binding agreement, easement, covenant, or contract enforceable by civil action and held by an organization or agency with a primary mandate for the long-term conservation of biodiversity	The mechanism is an international convention enforceable by sanctions	The mechanism is a land- or water-use plan or zone, whether government, corporate, NGO, First Nations, community, or private citizen, which is legally binding and enforceable	The mechanism is a policy, agreement, resource management plan, land- or water-use plan or zone, whether government, corporate, NGO, First Nations, community, or private citizen, which is not binding or enforceable	Is an international convention which is not enforceable

Table 8. Synopsis of seven MPA and fishery closure design,objectives and benefits from O'Boyle (2011; Table 1).

Closure	Temporal Extent	Excluded Activities	Permitted Activities	Objectives	Benefits relevant to Objectives	Collateral Benefits
Groundfish Closures US GOM	Year-round	All gear capable of retaining groundfish (trawls, gillnets, hook gear, and scallop dredges)	Lobster traps and mid-water trawls for small pelagic species	Reduction of exploitation rates of Georges Bank cod, haddock and yellowtail	Some reduction of fishing mortality on groundfish in the absence of quotas, particularly protection of juvenile haddock	Protection of sea scallop resulting in enhanced production; some benefits to community biodiversity; some benefits for protection of bottom habitat
Haddock Closure Browns Bank	Seasonal (March – mid-June)	All gear capable of retaining groundfish (trawls, gillnets, hook gear, and scallop dredges)	All other gear (e.g. lobster traps except in LFA 40)	Reduction of exploitation rate of Browns Bank haddock to low level; spreading of catch throughout year	Not effective in reducing Browns Bank haddock exploitation rates; protection of 4X cod and haddock spawners during spawning season	Due to seasonal nature of closure, additional benefits for habitat and ecosystem likely limited
Haddock Closure Emerald Bank	Year-round	All groundfishing	All other gear (e.g. lobster traps, scallop dredges)	Protection of juvenile 4VW haddock	Limited evidence that closure has been beneficial to overall haddock stock productivity (due to confounding growth declines)	Increases on abundance of non-target species in closed area, indicating broader beneficial effects throughout ecosystem; inferential evidence that expected benthic habitat improvements have improved juvenile haddock survival
Lobster Closure LFA 40	Year-round	Fixed lobster gear	Fixed and mobile groundfish gear and scallop dredges	Protection of mature female lobster; input control for inshore fleet; buffer zone between inshore and offshore fleets	In comparison to distributional range of early life and mature stages of lobster, likely only partial protection of stock from fishing pressure	There may be benefits in relation to protection of endangered species such as Right Whales and Leatherback turtles but these remain to be confirmed
Gully MPA	Year-round	Zone 1: all fishing	Zone 2 & 3: halibut, tuna, shark and swordfish fishing	Maintenance of productivity of Gully ecosystem; protection of natural biodiversity of Gully; protection of physical structure of Gully and its physical and chemical properties	Some protection of juveniles of 4TVW haddock stock; protection of marine turtles, bottlenose whales and other marine mammals to extent that they use Gully; protection of benthic fauna in Gully with expectation of increases in abundance of long-lived species with low turnover rates and growth of shelter forming epifauna (e.g., corals)	Protection of wide spectrum of ecosystem components

Closure	Temporal Extent	Excluded Activities	Permitted Activities	Objectives	Benefits relevant to Objectives	Collateral Benefits
Coral Conservation Closures Scotian Shelf	Year-round	Restricted fisheries zone: bottom – contacting gear	Limited fisheries zone: groundfishing using longline & handline with observer present	Minimization of impacts from human activities on coral communities; protection of and, where necessary, restoration of important coral habitats	Long-term protection of the deep-water coral communities	Protection and enhanced productivity of species (e.g. redfish) associated with coral communities; benefit to local ecosystem in immediate area of coral closure
Eastport Peninsula MPAs	Year-round	Depositing, discharging, or dumping of substances that result in disturbance, damage, destruction, or removal of any living organism or any part of its habitat	Any activity that does not disturb, damage, destroy or remove living marine organisms or their habitats	Maintenance of a viable population of lobster through conservation, protection, and sustainable use of resources and habitats; conservation and protection of threatened or endangered species (i.e. wolfish)	Likely higher productivity of lobster resources within MPA with potential spillover of adolescent and adult lobster to adjacent areas in the long – term; likely enhanced reproduction and contribution of lobster larvae to surrounding areas; localized protection of wolfish; localized protection of benthic fauna leading to localized increases in fish productivity over long-term	Protection of spectrum of ecosystem components, with focus on those relevant to lobster and endangered / threatened species

Table 9. Description of review articles used to identify ecological factors contributing to effective biodiversity protection.

Publication	Scope of Review	Focus of Review	Ecosystem Components Considered
Balmford et al. 2002	139 case studies from around the world	cost of conservation benefits	threatened bird species
Jameson et al. 2002	selected literature	business plan approach evaluating effectiveness	tropical corals are used as examples but framework is meant to apply broadly
Halpern 2003	89 selected studies	evaluation of size effects	carnivorous fishes, herbivorous fishes, planktivorous fishes/invertebrate eaters, and invertebrates
Palumbi 2004	selected literature	connectivity and MPA networks	selected literature
Laurel & Bradbury 2006	review of 429 MPAs	size of reserves in temperate systems; connectivity	north temperate fish species
Mora et al. 2006	review of 890 MPAs	design features	coral reef systems
McLeod et al. 2009	selected literature	design of MPA networks in light of climate change with a focus on biphysical indicators confering resilience	selected literature
Gaines et al. 2010	selected literature	size, shape, location of MPA networks	selected literature
Sciberras et al. 2013	scientific literature (4851 articles); 40 studies selected after systematic review; 63 MPA case studies considered	evaluation of effectiveness of closure regimes (no take, partial protection, open access)	fish assemblage density and biomass
Bennett & Dearden 2014	selected literature	factors leading to effective ecological and socioeconomic outcomes in MPAs	selected literature

Publication	Scope of Review	Focus of Review	Ecosystem Components Considered
Burt et al. 2014	peer reviewed literature and 5 reports from scientific panels and expert working groups	design of MPAs and MPA networks and relevance to British Columbia	selected literature
Cusson et al. 2015	meta-analysis of 28 data sets	relationship between biodiversity and stability of marine benthic assemblages	North Atlantic and western Mediterranean
Edgar et al. 2014	87 MPAs worldwide	evaluated properties which conferred the greatest conservation benefits (effectiveness)	broad but with a focus on tropical reef systems
McClanahan 2014	5 fisheries closures	evaluation of the effect of length of protection time on recovery of key ecological processes and functional groups	Kenyan tropical reefs; functional groups: marine plants, herbivores, carnivores, piscivores

Table 10a. Annotated summary of the conclusions made from a review of published review papers.(ND= not discussed in detail)

	Size	Spatial Relationships (Connectivity and Fragmentation)	Beta-Diversity	Length of Time Under Protective Measures	Mgt Strategies Outside of MPA	Location	Partial vs Full Protection
Balmford et al. 2002	One measure of potential conservation benefit is the total area conserved	ND	ND	ND	ND	ND	ND
Jameson et al. 2002	Small sized MPAs are not as effective at protecting mobile species, but larger MPAs are harder to manage. Therefore size is context dependent	ND	ND	ND	ND	MPAs should be placed away from outside stressors (atmospheric, terrestrial, and oceanic)	ND
Halpern 2003	Larger reserves are more likely to contain rare species. The relative impacts of reserves, such as the proportional differences in density or biomass, are independent of reserve size.	ND	ND	ND	ND	ND	ND
Palumbi 2004	Small marine reserves have the ability to prevent degradation of local fish species. Neighbourhood size of the species should be less than approximately twice the size of the reserve. Species migration dependent.	Adult neighborhood sizes for many demersal fish and invertebrates as small as kilometers and up to 10 to 100 km. Larval dispersal may be shorter than previously suspected: neighborhood sizes of 10 to 100 km for invertebrates and 50 to 200 km for fish are common in current compilations	ND	ND	ND	ND	Fully protected MPAs generally lead to a greater increase in species biomass
Laurel and Bradbury	MPAs placed in high latitudes may need to be much larger in	High latitude MPAs should be implemented as	ND	ND	ND	ND	ND

	Size	Spatial Relationships (Connectivity and Fragmentation)	Beta-Diversity	Length of Time Under Protective Measures	Mgt Strategies Outside of MPA	Location	Partial vs Full Protection
2006	size in order to be effective	either single reserves or a network of reserves					
Mora et al. 2006	Large enough to allow for effective dispersal. 10-20 km sq in diameter	MPAs should be spaced approximately 15 km from one another	ND	ND	Many coral MPAs are vulnerable to outside impacts (sedimentation, human acitivities, pollution, etc).	ND	Majority are multipurpose MPAs
McLeod et al. 2009	Large enough to protect the full range of marine habitat types and the ecological processes on which they depend	Connectivity for mobile species and habitats. Max spacing 15-20km apart for larval dispersal	Protect at least 20-30% of each habitat type. Protect at least 3 examples of each marine type	ND	Ecosystem based management	Spread out protected areas will reduce the chance that multiple MPAs will be effected by a disturbance	No take recommended
Gaines et al. 2010	Large reserves are more likely to achieve a conservation benefit. Smaller reserves should be scaled up.	Connectivity or a network of MPAs can aid with larval dispersal and overall fish prosperity	Reserve placement should be in all major marine habitats (representative)	Reserve protection should be permanent to increase awareness and enforcement	MPA success is often tied to the fisheries outside the reserve area. If the area directly outside the MPA is degraded then the conservation benefit of the reserve is decreased	Reserves should be placed in source locations and fish larval sinks	ND
Sciberras et al. 2013	ND	ND	ND	ND	ND	ND	No-take reserves provide some benefit over less protected areas. Significant

	Size	Spatial Relationships (Connectivity and Fragmentation)	Beta-Diversity	Length of Time Under Protective Measures	Mgt Strategies Outside of MPA	Location	Partial vs Full Protection
							ecological effects of partially protected areas relative to open access areas suggest that partially protected areas are a valuable spatial management tool.
Bennett & Dearden 2014	Larger reserve size leads to greater fish reserve density	Networks improve species dispersal.	ND	ND	Reserves should be nested within integrated coastal zone management areas, or ecosystem based management areas.	Location of an MPA is context dependent (social, ecological, and cultural)	No take (full protection) yielded greatest conservation benefits
Burt et al. 2014	Size should at least be as large as the average larval dispersal distance of targeted species and encompass the adult home range or neighbourhood size	Maintaining the ecological connectivity, by ensuring that individual MPAs are adequately spaced (20-100km), is necessary to ensure functionality.	ND	Protection measures should be designed to be long term	Conservation of mobile species will require sustainable management strategies outside the protected area	Dependent on type of species / habitat being protected	No-take MPAs (full protection) are more desirable than MPAs that allow some human activities. However, partially protected areas can still offer some benefit

	Size	Spatial Relationships (Connectivity and Fragmentation)	Beta-Diversity	Length of Time Under Protective Measures	Mgt Strategies Outside of MPA	Location	Partial vs Full Protection
Cusson et al. 2015	Impossible to standardize size as a screening tool without reference to the target species	ND	ND	ND	ND	ND	ND
Edgar et al. 2014	MPA size (> 100 km^2) plus other factors	ND	ND	Old (> 10 years)	ND	Isolated by deep water or sand	No take (full protection) yielded greatest conservation benefits
McClanahan 2014	ND	ND	ND	Total consumer biomass peaked at 15-20 yr, but the magnitude and time scale of other functional group responses varied and were not always predictable. Functional group recovery was not fully complete by ~35 yr of closure	ND	ND	ND
Summary of Review	Context dependent; Can be a good proxy for effectiveness in some situations and when combined with other factors	Important consideration especially for mobile species protection	A variety of different habitats indicative of higher biodiversity	Not often discussed; when discussed long-term protection leads to conservation benefits	MPAs placed inside degraded or heavily impacted areas are less likely to be effective	Context dependent	No-take MPAs lead to conservation benefit; partial closures can produce significant benefits

Table 10b. Annotated summary of the conclusions made from a review of published review papers.(ND= not discussed in detail)

	Density, Size and Age Structure of Key Species	Biodiversity Objectives	Naturalness of the area	Legal or social authority that created the MPA	Types of enforcement / surveillance	Top-down / Bottom-up / Other	Monitoring / evaluation / adaptive measures
Balmford et al. 2002	ND	ND	ND	ND	ND	ND	ND
Jameson et al. 2002	ND	ND	ND	Government	Lack of enforcement is a primary reason MPAs become inefficient - "paper parks"	Community capacity and Institutional capacity	Monitoring is important in evaluating if conservation objectives are being achieved
Halpern 2003	Density, biomass, size of organisms, and diversity is higher in reserve rather than outside the overall communities and by each functional group within the communities (carnivorous fishes, herbivorous fishes, planktivorous fishes/invertebrate eaters, and invertebrates).	ND	ND	ND	ND	ND	ND
Palumbi 2004	ND	ND	ND	ND	ND	ND	Monitoring is important in evaluating effectiveness
Laurel and Bradbury 2006	ND	ND	ND	ND	ND	ND	ND

	Density, Size and Age Structure of Key Species	Biodiversity Objectives	Naturalness of the area	Legal or social authority that created the MPA	Types of enforcement / surveillance	Top-down / Bottom-up / Other	Monitoring / evaluation / adaptive measures
Mora et al. 2006	ND	ND	ND	ND	Less than 0.1% and in an area that is classified as no-take	ND	Many coral MPAs do not have effective enforcement decreasing their overall conservation value
McLeod et al. 2009	ND	Critical areas should be protected: nursery grounds, spawning aggregations, areas of high diversity	More natural areas require less monitoring (i.e. water quality monitoring)	ND	Types not discussed - just stated that effective enforcement is desirable	ND	Monitoring is important in evaluating if conservation objectives are being achieved
Gaines et al. 2010	Older fish within a protected area will produce more offspring, resulting in greater larval dispersal to fished areas	ND	Isolated areas contribute more to Marine reserves worldwide	ND	Poaching can be an issue for marine reserves if enforcement is not effective	ND	ND
Sciberras et al. 2013	ND	ND	ND	ND	ND	ND	ND
Bennett & Dearden 2014	ND	Clear conservation and social objectives should be created	ND	Usually government	Effective enforcement is essential, no specific types of enforcement were discussed	Co-management	Management should be adaptive. Participatory monitoring

	Density, Size and Age Structure of Key Species	Biodiversity Objectives	Naturalness of the area	Legal or social authority that created the MPA	Types of enforcement / surveillance	Top-down / Bottom-up / Other	Monitoring / evaluation / adaptive measures
Burt et al. 2014	ND	ND	ND	Typically governmental. Governance rules and regulations should be integrated and harmonized when different levels of government are involved in implementing an MPA	Enforcement of rules should be impartial and fair. No specific types of enforcement were discussed	If top-down, constructive stakeholder dialogue will help to build trust and awareness	Monitoring and enforcement should be effective and credible, but no specific types of monitoring were discussed. Adaptive management is desirable in light of new information or changing circumstances
Cusson et al. 2015	ND	ND	ND	ND	ND	ND	ND
Edgar et al. 2014	ND	ND	Isolated would imply more natural	ND	Well enforced. No specific measures discussed	ND	ND
McClanahan 2014	ND	ND	ND	ND	ND	ND	ND

	Density, Size and Age Structure of Key Species	Biodiversity Objectives	Naturalness of the area	Legal or social authority that created the MPA	Types of enforcement / surveillance	Top-down / Bottom-up / Other	Monitoring / evaluation / adaptive measures
Summary of Review	Outcome strongly associated with effectiveness	Rarely discussed	Rarely discussed with respect to effectiveness	MPAs are often implemented by governmental organizations	Specific types of enforcement were not discussed. In general, enforcement is necessary to ensure conservation objective are being met	Rarely discussed	Monitoring is an important part of ensuring a PA is effective. Adaptive management aids with keeping PAs effective