

# Marine Connectivity Conservation<sup>1</sup> 'Rules of Thumb' For MPA and MPA Network Design

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## Center for Large Landscape Conservation (CLLC)

CLLC develops solutions, implements projects and contributes to global efforts that connect and protect crucial habitat across terrestrial, marine and freshwater ecosystems. It provides expertise through four key focus areas: science and research, mentorship and networking, community resilience and policy. By bringing knowledge and experience to bear on connectivity conservation issues worldwide, the Center works with communities, governments and other stakeholders to stop fragmentation and safeguard the legacy of protected and conserved areas by making them part of larger ecological networks for conservation.

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## WCPA Connectivity Conservation Specialist Group (CCSG)

CCSG was established in 2016 under the IUCN World Commission on Protected Areas (WCPA) to support information sharing, active participation, global awareness, and action to maintain, enhance, and restore ecological connectivity conservation around the world. Its objective is to advance the science, policy, and practice at international, national, and subnational levels to meet the growing demand for solutions that advance the identification, recognition, and implementation of consistent connectivity conservation measures.

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## IUCN WCPA Connectivity Conservation Specialist Group's Marine Connectivity Working Group (MCWG)

MCWG provides expertise to support enhanced conservation of the natural linkages that connect critical marine habitats, facilitate species movement, and sustain ecosystem functions between marine protected areas, conserved areas (aka OECMs), and other intact areas, including Key Biodiversity Areas and World Heritage Sites.

Additional members, partners, and supporters are actively sought as collaborators to advance knowledge about scientific, policy, governance and outreach for building innovative marine connectivity policies, programs, and practice on the ground.

[www.conservationcorridor.org/ccsg/working-groups/mcwg/](http://www.conservationcorridor.org/ccsg/working-groups/mcwg/)



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*Whale Shark, a highly migratory species, seen on Ningaloo Reef, Exmouth, Western Australia.*

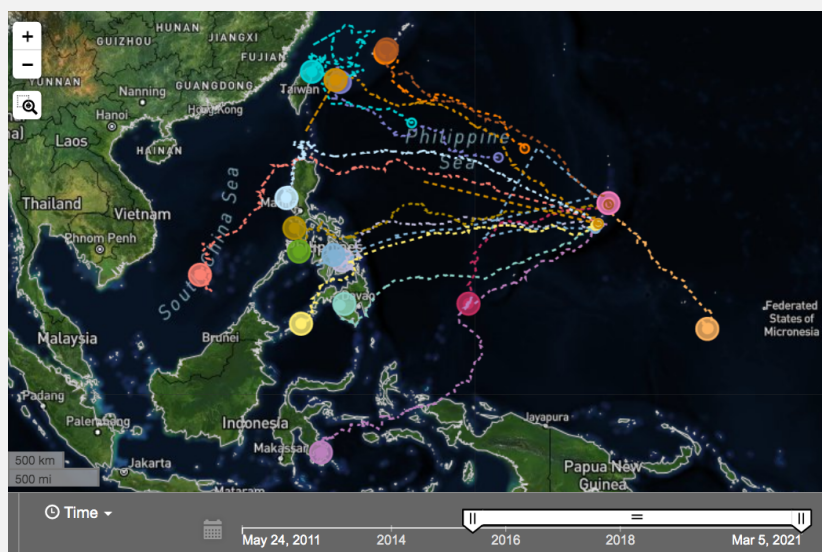




## Introduction

Marine Protected Areas (MPAs)<sup>2</sup> are widely used as place-based protective measures for restoring and safeguarding marine biodiversity (species, genetic resources, ecosystems). To design effective and resilient MPAs and coherent networks of MPAs (Rees et al., 2018), it is necessary to take into account ecological connectivity<sup>3</sup> (generally referred to as 'connectivity') which allows populations to thrive and biodiversity and ecosystem services to be maintained (Carr et al., 2017; UNEP-WCMC, 2018 b). Gradual resource depletion of an MPA may negatively impact connectivity of wildlife populations. Because a well-functioning ecosystem or habitat provides wildlife populations with their basic survival needs for food, shelter, water, and space, if any of these basic needs is depleted or degraded, connectivity of some populations may no longer be feasible. Connectivity concepts can differ based on scale and can apply to individual MPAs and MPA networks independently or collectively, depending on ecosystem or marine species characteristics.

To date, ecological connectivity is among the most infrequent and ineffectively applied ecological criteria in MPA design and evaluation (Magris et al., 2014; Balbar and Metaxas, 2019), often because it is difficult to measure (White et al., 2019; Balbar and Metaxas, 2019). However, connectivity is increasingly being studied in marine systems with enhanced efforts to overcome technical and logistical challenges (e.g., White et al., 2013; Botsford et al., 2014).



*Endangered Green Turtle migrations demonstrate connectivity from the Mariana Archipelago across international waters to various jurisdictions, including Japan, Philippines, Indonesia and Palau (NOAA ATN DAC DATA Portal).*

## Background

When science has gaps, uncertainties, and as yet significantly unexplored domains, as is the case with connectivity in the marine environment, practical 'rules of thumb' can provide basic guidance

1. In this note, 'connectivity conservation', in the most basic terms, means "a conservation measure in natural or semi-natural areas that are interconnected and in environments that are degraded or fragmented by human impacts and development where the aim is to maintain or restore the integrity of the affected natural ecosystems, linkages between critical habitats for wildlife, and ecological processes important for the goods and services they provide to nature and people." (Lausche et al., 2013).
2. IUCN defines a protected area, including an MPA, as: 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 definition will make it much harder for actions that involve exploitation, such as fisheries, to be claimed as MPAs that protect the ocean. If marine areas involve extraction and have no defined long-term goals of conservation and ocean recovery, they are not MPAs.
3. Ecological connectivity means the unimpeded movement of species and the flow of natural processes that sustain life on Earth" (CMS, 2020).



for planning and management (Lubchenco et al., 2019). This approach is increasingly used in the planning and review of MPA networks (Carr et al., 2010; Saarman et al., 2013; Burt et al., 2014; Smith and Metaxas, 2017; Balbar and Metaxas, 2019), and can facilitate complementary management approaches across marine jurisdictional boundaries (UNEP-WCMC, 2018 a). Access to data on migratory movements is increasing rapidly through tracking technologies and improved data sharing (Dunn et al., 2019). For example, OCEARCH scientists and partners tag great white sharks using GPS-tags with sophisticated remote sensing systems tracked globally through satellites, then live-stream and provide open source data for use by scientists and safety programs (OCEARCH Shark Tracker). Spatial conservation planning tools are also being modified to enable the consideration of ecological connectivity in decision making (Daigle et al., 2020; Virtanen et al., 2020). In some locations, local community and Indigenous ecological knowledge have generated valuable information on marine ecological connectivity for management (Le Fur et al., 2011; Berkström et al., 2019).



*Bigeye Scad and Anthias fish on Bytes Coral Reef, Indian Ocean, Maldives.*

## Science and policy considerations

A well-designed MPA network can support connectivity needs while also meeting other important ecological criteria. In contrast, weak ecological connectivity may hinder the ecological performance, including resilience, of MPA networks, in turn reducing the flow of ecosystem services and ecosystem benefits with potentially negative consequences for [nature and] human well-being (Olds et al., 2016; Rees et al., 2018). Several legal instruments for meeting ecological criteria also address marine connectivity (Lausche et al., 2013).

The Convention on Migratory Species adopted a policy resolution in 2020 stating that “Ecological connectivity is the unimpeded movement of species and the flow of natural processes that sustain life on Earth” (CMS, 2020) and should be a key factor in the conservation of management units, including in the marine environment.

Under the Convention on Biological Diversity, Aichi Biodiversity Target 11: by 2020, “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” (CBD Strategic Plan for Biodiversity 2011-2020). Aichi Target 11 requires signatories to design and manage protected areas and the connections between them to protect biodiversity and in part to address the impacts of climate change on shifting species distributions. A renewed and stronger focus on connectivity is anticipated through broad-scale application of the ecosystem-based approach to spatial planning under the expected Post-2020 global biodiversity framework (CBD/WG2020/2/4).





## Definitions

Various scientific definitions related to ecological connectivity are useful when thinking about how to incorporate connectivity into MPAs and MPA networks (Hilty et al., 2020). It is important to note that application of these sub-definitions is most advanced in terrestrial environments. Application to marine environments requires special attention to their distinct features: three-dimensional space and the fluid nature of the sea where organisms may move horizontally, vertically, or diagonally; the large-scale connectivity of natural processes; high physical and abiotic environmental variability; ecosystem linkages between coastal waters, national waters and the high seas; and how climate change may affect circulation patterns, food sources, water chemistry, and the land-sea interface. With that caveat, definitions related to ecological connectivity include (adapted from Hilty et al., 2020):

**Ecological connectivity for species:** The functional movement of populations, individuals, genes, gametes and propagules between populations, communities and ecosystems, as well as the structural connection of non-living material from one location to another;

**Functional connectivity for species:** A description of how well genes, gametes, propagules or individuals move through land, freshwater, and the ocean;

**Structural connectivity for species:** A measure of habitat permeability based on the physical features and arrangements of habitat patches and stepping stones, disturbances, and other land, freshwater or ocean elements presumed to be important for organisms to move through their environment. Structural connectivity is used in efforts to restore or estimate functional connectivity where measures of it are lacking;

**Ecological corridors:** A clearly defined geographical space that is governed and managed over the long term to maintain or restore effective ecological connectivity. The following terms are often used similarly: 'linkages', 'safe passages', 'ecological connectivity areas', 'ecological connectivity zones', and 'permeability areas';

**Ecological network (for conservation):** A system of core habitats (terrestrial or marine protected areas, OECMs and other intact natural or semi-natural areas), connected by ecological corridors, which is established, restored as needed and maintained to conserve biological diversity in systems that have been fragmented.

*Kelp, providing juvenile fish nursery habitat in the Channel Islands, California.*



# Marine Connectivity Conservation 'Rules of Thumb' (RoTs) For MPA and MPA Network Design



*Green Turtle surfacing for air in the Maldives.*

1

Ecological connectivity (generally referred to as 'connectivity') should always be considered in the design of an MPA or MPA network, using best available science.

2

Management strategies and spatial plans for MPAs and MPA networks should include attention to the role of marine connectivity in the face of current and anticipated climate change, both near and long term projections, and establish interconnected MPA networks to preserve and strengthen connections and transition zones to allow for possible shifts in species distribution or ecosystem functions due to climate.

3

Design and management of MPAs and MPA networks where climate change resilience is an objective must take into account the effects of ocean processes (for example, currents, vertical movements, temperature variation and chemical changes, interaction of the ocean with the atmosphere, and land-based processes (for example, nutrient flows, sedimentation, the water cycle, storms and other natural disturbances) on connectivity of affected target species, as well as climate uncertainties and the need for appropriate buffers as part of adaptive management.





4

When determining whether connectivity should be incorporated into the design of an MPA network, it is essential to identify the role that each MPA plays in supporting connectivity as well as barriers to connectivity. For example, the existence of self-replenishing populations may support connectivity and persistence of an MPA network, whereas other MPAs in a network may serve as sources, stepping-stones or corridors that connect widely distributed species (Balbar and Metaxas, 2019). In other scenarios, it may be sufficient to simply protect a large proportion of habitat, regardless of connectivity pathways (Cabral et al., 2016). This could be the case if different target species have vastly different connectivity patterns (White et al., 2014). It is also important to take into account those connectivity processes that may have undesired consequences by connecting dispersal routes for invasive species, pathogens, pollution, and ecosystem disruptive algal blooms.

5

When connectivity is to be implemented in the design of an MPA network, management units should be scaled based on realistic connectivity patterns, incorporating best available scientific information, with potential for adaptations in response to climate change. Larval dispersal and adult movement and size of home ranges are key factors in determining the spatial scale of the management unit and varies among target species. Species with short dispersal distances and low representation in networks may be more vulnerable to stressors, whereas species with long-range movement or migrations as larvae or as adults (such as pelagic species) may require larger protection areas or may need connectivity between nursery areas and adult habitat and still spend substantial periods in unprotected areas.

6

To protect and leverage the many forms of ecosystem connectivity, the siting and design of individual MPAs should include multiple ecosystems (e.g., coastal nurseries and offshore adult habitats) so that the resulting MPA network encompasses a diversity of marine habitats across broad spatial scales and where possible the anticipated climate-driven shifts in species ranges (Green et al., 2015). Where there may be uncertainty about negative impacts from global change/climate change, it will be necessary to include that in the assessment of connectivity needs over the near and long term and introduce adaptive management (Magris et al., 2014; Wilson et al., 2020).

7

For marine species that use different habitats throughout their life cycle or are likely to be impacted by threats from land or sea, a multi-management approach is needed across realms. This includes consideration of land-sea connectivity (Storms et al., 2005). A source-to-sea approach will often be advisable when dealing with littoral landscapes or diadromous species. In addition, land-sea connectivity should include nesting islands of pelagic seabirds, such as albatrosses, which are dependent on marine connectivity.

8

Because well-functioning MPAs help fisheries and ecosystems, overfishing combined with climate change and habitat destruction requires that connectivity analyses recognize the interrelationship between MPA management (whether near-shore or deep sea) and management of commercial fisheries outside MPAs with respect to spillover pollution, habitat maintenance, possible quotas, and monitoring what is caught (larval, juvenile, adult).



9

In deep waters where mining operations (minerals, oil, gas) are being considered, initiatives to design and establish MPAs or MPA networks should be preceded by a regional environmental assessment and management plan (conducted by the government if in national waters or the responsible international agency if in the areas beyond national jurisdiction) identifying, as best possible, potential negative mining impacts, including disturbances to the seabed, mid-water ecosystems and surface, and indicating those habitats, ecologically important areas, connectivity needs (including genetic connectivity) and resilience features to conserve through a network of no-mining zones, either as formal MPAs or as 'areas of particular environmental interest' (APEIs) with the goal of protecting 30 to 50 percent of each deep sea management area (Pew Charitable Trusts, 2018).

10

International cooperation is essential for negotiating and establishing ecological corridors and management plans across borders and at larger scales. Several important international and regional legal instruments applicable to marine environments and their conservation can be used to promote such cooperation. These instruments highlight obligations and commitments in international law, policy, and programs that countries can also use to support, defend, and pursue national actions incorporating marine connectivity as part of MPA and MPA network design and implementation. Prominent among these are the UN Convention on the Law of the Sea, the Convention on Biological Diversity, the Convention on Migratory Species and its agreements and MOUs, and The Ramsar Convention (Lausche et al., 2013).

11

Habitat suitability modeling should be used where there are limited data on spatial distribution of target species, communities, or ecosystems in order to develop scenarios that can provide some information on habitat linkages and species dynamism<sup>4</sup>. For example, habitat suitability modeling of vulnerable marine ecosystem (VME) indicator taxa was used in the South Pacific Ocean to inform deep-sea fisheries management. Habitat suitability modeling can support improved spatial management where data is lacking (Georgian et al., 2018).

12

Where data are limited for the many species targeted for protection by MPAs, size and spacing recommendations for an MPA network can be based on a few species that represent the diversity of larval dispersal and adult home range distances as well as distances from juvenile nurseries to adult habitat (Weeks, 2017).

13

In addition to ecological connectivity, the following criteria are important to reflect in MPA provisions guiding the selection and design of particular sites; representativeness, replication, viability, precautionary design, prominence, maximum connectivity, resilience, minimizing adverse impacts on existing users, and cultural values (CBD COP 2004 VII/5).

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4. According to NOAA's National Marine Protected Areas Center, building ecologically connected marine networks requires, among other things, "the identification of climate change refugia and modeling of future impacts of climate change for incorporation into MPA networks, and the development of new monitoring programs to demonstrate the effects of connectivity over time" (Cannizzo et al., 2020).





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*Red Mangrove stand in Sumbawa, Indonesia*