MARINE PROTECTED AND CONSERVED AREAS IN THE TIME OF COVID

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ABSTRACT

The intersection of potential global targets and commitments for ocean conservation with the COVID-19 pandemic in 2020 has resulted in an opportunity to rethink the future of marine area-based conservation tools, particularly for marine protected and conserved areas (MPCAs). As MPCAs continue to provide essential ecological, social and economic services, current approaches to establishing and managing these areas require an understanding of the factors that drive the pressures they face. We briefly review their status pre-pandemic and provide an overview of the impacts of COVID-19 informed primarily by 15 case studies. Impacts are of two kinds: those affecting livelihoods and well-being of local communities and stakeholders that depend on the MPCA; and those which affect management and governance of the MPCA itself. Responses from managers and communities have addressed: the management of resources; income and food security; monitoring and enforcement; seafood supply chains; and communication amongst managers, community members and other stakeholders. Finally, we discuss innovative approaches and tools for scaling and transformational change, emphasising synergies between management for conservation and management for sustainable livelihoods, and how these relate to the principles of equity and resilience.

Key words: communities, resilience, innovation, pandemic, coronavirus, sustainable financing, impacts and response, technology, blockchain

INTRODUCTION

The COVID-19 pandemic caused by a novel coronavirus, SARS-COV-2, is a symptom of the much larger crises – of climate change, a burgeoning global population and growing inequity – that affect both humanity and the natural world (Díaz et al., 2019). Its impacts on the support given to nature are already apparent, with many governments redirecting resources towards healthcare and economic development (Hockings et al., 2020). The negative effects are being especially felt in protected and conserved areas, a key tool in biodiversity conservation and sustainable use of natural resources, including in the marine environment. This is despite the fact that a new found appreciation for green and natural spaces has occurred during lockdowns in many countries, giving hope that the true value of nature will be better captured during recovery from the pandemic.

For MPCAs, this moment is critical, given the growing understanding of the essential contributions they make towards biodiversity conservation, sustainable fisheries and human well-being (Brander et al., 2020). The year 2020 came with high expectations that countries would

Fisherman drying freshly caught fish on Mafia Island, Tanzania ©Green Renaissance / WWF-UK

agree to ambitious commitments to make ocean-based economies more sustainable, protect marine biodiversity and create ecologically and socially resilient MPCAs, and manage the oceans to help address climate change. Instead, the pandemic changed the course of the global policy calendar: meetings were postponed or held virtually, and progress dramatically slowed. However, the crisis provides an opportunity to re-examine mechanisms, interventions, management and governance structures so that we can better manage future 'shocks', such as pandemics, extreme climate events or financial crises.

Adapting current approaches to establishing and managing MPCAs in a changing world requires a reflection on the successes and failures of marine conservation, and on how different approaches have been affected by the pandemic. Our paper aims to: (1) review the status of MPCAs pre-pandemic; (2) provide an overview of the impacts of COVID-19, using 15 case studies (Table 1) and other sources; and (3) propose innovative approaches for scaling-up and transformational change to secure a more effective, ethical and resilient future for MPCAs in a post-COVID world. We use the term MPCAs throughout this paper to include all forms of marine protected areas (MPAs) (whether highly protected or multiple use), as well as Other Effective Area-based Conservation Measures (OECMs) such as Locally Managed Marine Areas (LMMAs), in line with current and more inclusive thinking on area-based management.

WHERE WE WERE PRE-PANDEMIC

There is global consensus that the health of the marine environment is declining due to multiple anthropogenic pressures, including climate change, unsustainable fisheries and growing coastal and ocean development (Northrop et al., 2020), with most MPCAs failing to effectively address these stressors. Aichi Target 11 calls for the effective protection of 10 per cent of coastal and marine areas, a target which has not been met either globally (currently 7.77 per cent of marine waters are within MPCAs; www.protectedplanet.net/en), or, in most cases, nationally. Countries have also largely failed to meet the qualitative aspects of Aichi Target 11, namely that MPCAs should be well-connected, ecologically

representative, and equitably and effectively managed. There are numerous obstacles to achieving success, including poor governance, lack of political will, weak institutions and limited management capacity (Bennett et al., 2017). Gill et al. (2017) found that 90 per cent of MPCAs surveyed reported below optimum or inadequate staff capacity, and 65 per cent reported insufficient budgets; only half of MPCAs stated that locals were directly involved in decision-making. The lack of consensus on suitable indicators or levels of protection needed for effective marine conservation (e.g. Agardy et al., 2016; Sala et al., 2018) have hindered MPCA evaluation, and are now under detailed discussion as the post-2020 Global Biodiversity Framework is developed (CBD, 2019; Geldmann et al., 2020).

Equitable governance of MPCAs and fair benefit sharing are of growing importance to stakeholders more generally, yet many MPCAs lack inclusive governance processes (Gill et al., 2017; Zafra-Calvo et al., 2019). Since the Sustainable Development Goals (SDGs) elevated the importance of joint social-environmental agendas, the need to address the main barriers to mainstreaming equity and inclusion within MPCAs has become clearer. Formal institutions for governing MPCAs are often separated from those responsible for social development, leading to siloed approaches. Equitable forms of MPCA governance often require that power be devolved to local levels, which can be met with resistance from those in authority. Local actors often have limited capacity or regulatory support for their roles (Cudney-Bueno & Basurto, 2009). And, while there is more research on the social dimensions of MPCAs, we still lack data on their social impacts (Ban et al., 2019), and on how best to design MPCAs so that they deliver more equitable benefits in diverse contexts (Gill et al., 2019). Ensuring equitable benefit sharing remains a key challenge to those working at the intersection of conservation and development, and specifically in relation to the role of fisheries in food security (e.g. Hicks et al., 2019).

WHERE WE ARE NOW – THE IMPACT OF THE PANDEMIC

To understand the effects of the pandemic on MPCAs and the subsequent responses of communities and managers, we gathered published studies from the literature, and compiled 15 new case studies from different geographies, with diverse management and governance structures. We refer to the new case studies throughout by superscript citation codes (Table 1). Due to the availability of information, these new case studies mostly focus on coastal or nearshore MCPAs (with the exception of Hawaii, USA[CS1]), which represent the majority of existing MPCAs (UNEP-WCMC et al., 2018).

Table 1. Marine Protected and Conservation Area (MPCA) case studies and their respective citation codes. Full case studies available in Supplementary Online Material.

Code	MPCA	Authors
CS1	Papahānaumokuākea Marine National Monument, Hawaii, United States	Wenzel & Clark
CS2	Galápagos Marine Reserve, Galápagos, Ecuador	Izurieta et al.
CS3	Northern Belize Coastal Complex, Belize	Kyne et al.
CS4	Florida Keys National Marine Sanctuary, Florida, United States	Wenzel & Fangman
CS5	Dutch Caribbean, Netherlands	Bervoets & Wells
CS6	Adriatic Sea Marine Protected Areas, Croatia and Italy	Vallarola & Prvan
CS7	Kanamai-Mtwapa Co-Management Area, Kenya	Kawaka et al.
CS8	Mafia Island Marine Park, Tanzania	Ndagala & Medard
CS9	Velondriake Locally Managed Marine Area, Madagascar	Oates et al.
CS10	Seychellois Marine Protected Areas, Seychelles	Shah & Wells
CS11	Tun Mustapha Park, Sabah, Malaysia	Jomitol et al.
CS12	Nusa Penida Marine Protected Area, Bali, Indonesia	Sanjaya et al.
CS13	Raja Ampat Marine Protected Area Network, West Papua, Indonesia	Awaludinnoer et al.
CS14	Great Barrier Reef Marine Park, Queensland, Australia	Hockings
CS15	Vatu-i-Ra Conservation Park, Ra Province, Fiji	Mangubhai

Table 2. Observed impacts of, and responses to, COVID-19 on Marine Protected and Conservation Areas reported in case studies (Table 1) and recent literature. Framework adapted from Gill et al. (2017)

Domain	Indicator	Impacts and responses drawn from the case studies
Procedural effectiveness	Budget capacity	• Decline in tourism income through MPCA user fees, sales, etc. created significant budget shortfalls. • Changes in government priorities (i.e. focus on COVID-19) reduced some MPCA budgets. Elsewhere, governments have made up shortfalls from lost tourist revenue. • In some very select cases, trust funds and private foundations provided emergency funding to retain management capacity.
	Staffing capacity/presence	• Reduced staff capacity and presence due to layoffs because of budget cuts, travel and quarantine restrictions and sickness preventing staff working.
	Implementation of planned management activities	• Reductions in MPCA management activities due to cuts in budget and capacity in state-run MPCAs. • Timelines extended for planned activities due to slower rate of work. • Management facilities not available for original uses as repurposed for COVID-19 health responses.
	Degree of monitoring (management, resource conditions, users)	• Ecological monitoring programmes halted. • Tourism operators or local community members trained to assist with monitoring (and paid as a means of income support).
	Level of enforcement	• Reduced frequency of patrolling and enforcement in some MPCAs. • Increased surveillance in some community MPCAs. • Increased time for training due to reduction in other management activities.
Procedural equity	Degree of stakeholder involvement in decision-making	• Changes in jurisdictional authority or priorities for local government bodies and MPCA managers (primarily due to implementation of emergency guidelines and protocols) have altered stakeholder engagement in MPCA management activities. In some cases, this has led to more coordinated decision-making and enforcement within MPCAs.
	Degree of devolution of management authority	• Where staff capacity was reduced, some enforcement was devolved to local communities. • MPCA community surveillance groups have increased collaboration and information-sharing with State-led enforcement agencies.
Substantive effectiveness	Status or change in well-being of affected communities	• Loss of livelihoods for many communities and stakeholders dependent on MPCA tourism. • Seafood supply chains disrupted with reduced markets affecting fishing in MPCAs.
	Status or change in threats to resource conditions	• Reduced disturbance to species and habitats from visitor activities. • Increased pressure on resources due to return to subsistence livelihoods in some places and increased coastal populations as people return from work to home communities. • Increased illegal extractive activities in many MPCAs.
	Status or change in species or habitat condition	• Perceived increase in abundance and behaviour change of certain species due to reduced disturbance.
Substantive equity	Relative distribution of ecological and social costs and benefits across social groups	• Differential impacts on stakeholders dependent on MPCAs according to livelihoods, geographical location and gender.

The main impacts of, and responses to, COVID-19 on MPCAs as documented in recent publications and our case studies are summarised in Table 2. We recognise that impacts differ between MPCAs as well as between geographic regions. To structure the analysis, we adapted the framework provided by Gill et al. (2017) which distinguishes MPCA management and performance topics into four domains: (1) appropriateness of management activities and capacities (procedural effectiveness); (2) fairness or justness of management (procedural equity); (3) achievement of desired MPCA outcomes (substantive effectiveness) and:

(4) distribution of MPCA costs and benefits (substantive equity).

COVID-19 has resulted in both negative and positive changes (Figure 1). The major impact for MPCAs where tourism is a key element has been the dramatic decline in tourism-related revenue (Hudson, 2020). Marine tourism alone, on which millions of people depend, was valued in 2016 at US$ 390 billion globally (OECD, 2016) and has been growing rapidly. Its decline led to significantly reduced funds for management and for livelihoods dependent on MPCAs. This is visible across all four domains (Table 2), though we found no examples of MPCAs that ceased to operate in 2020. Nonetheless, several positive responses have emerged, providing new ways of working that may be retained into the future.

Pandemic Impacts on procedural effectiveness

Budget and staff capacity

The dramatic fall in tourism activity has severely affected many governments and MPCAs that relied on

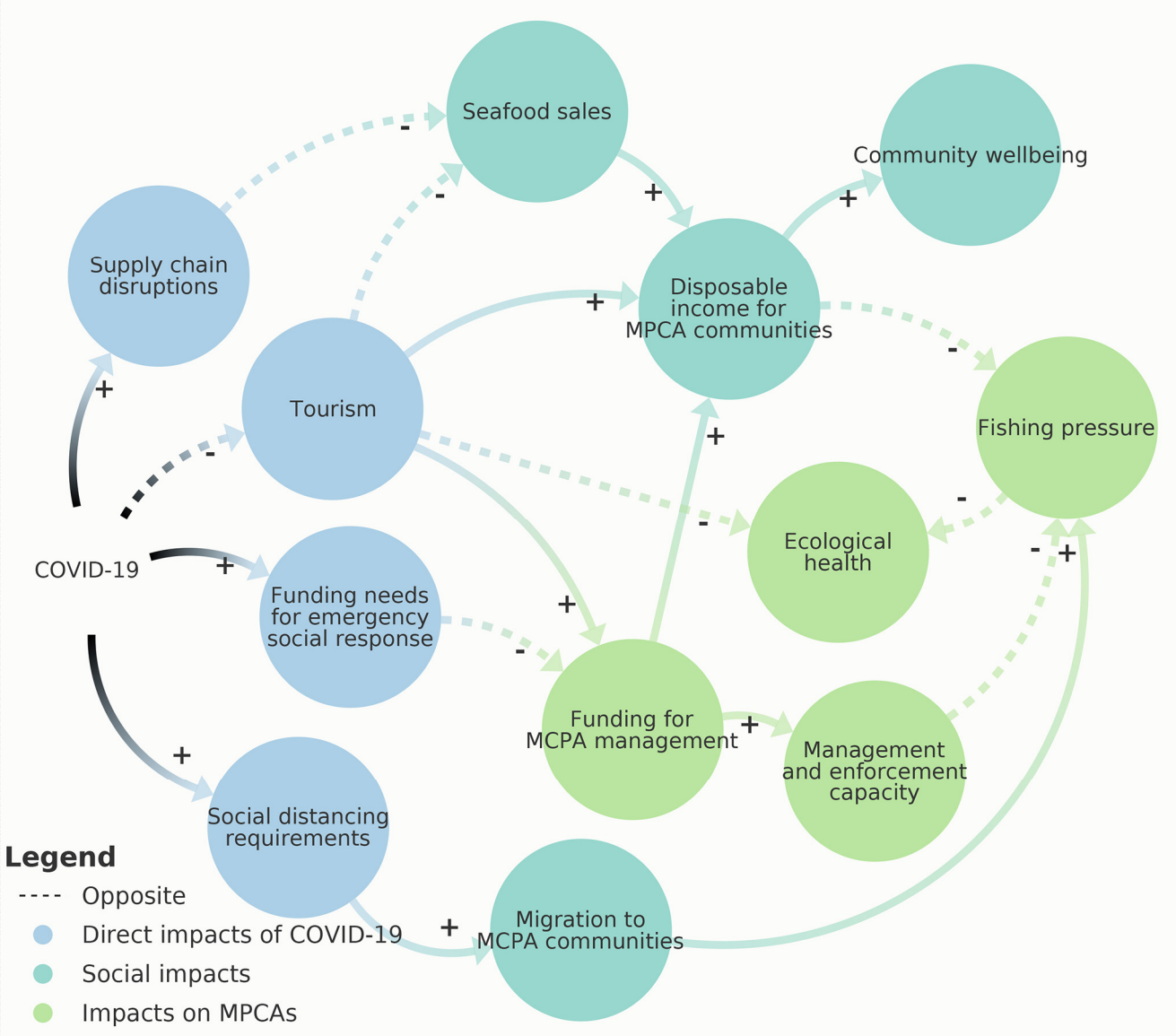

Figure 1. Impacts of COVID-19 on MPCAs and adjacent communities. This causal loop diagram shows the impacts documented in the case studies from COVID-19 on MPCAs and MPCA-dependent communities. Positive relationships (solid lines with a + sign) indicate variables that are reinforcing: when one goes up, the other goes up. Negative relationships (dotted lines with a - sign) indicate variables that have opposite relations: when one goes up, the other goes down.

tourism to fully or partly finance MPCA budgets. For example, Mafia Island Marine Park (Tanzania) depends solely on tourism operators, visitor fees and issuance of fishing permits for income, which then provides revenue for other MPAs in the country. Reduced funding has virtually halted management throughout the national MPA network.[CS8] The budget for Nusa Penida MPA (Indonesia) was significantly reduced by loss of tourism fees (there were 2,000 tourists/day pre-pandemic and only 20-30 tourists/day in September 2020), and a 50 per cent cut in government funding which pivoted to prioritising COVID-19 responses.[CS12] Some governments made up lost revenue from tourism (e.g. the Australian Government provided the Great Barrier Reef Marine Park Authority (GBRMPA) with additional funds[CS14]); in other cases, private foundations or Trust funds stepped in to provide emergency funding.[CS5, CS13]

Loss of income led to reduced staff capacity or activity (Figure 1), often compounded by sickness, quarantine requirements and/or travel restrictions preventing staff working (e.g. Tanzania[CS8], Raja Ampat[CS13]). In some cases, staff were laid off, though managers in some MPCAs tried to balance cuts across all activities to enable core management functions to be maintained (e.g. Raja Ampat[CS13]). In the Galápagos, concerns about spreading COVID-19 between islands led to restrictions on staff movements between different parts of the MPA.[CS2] Some MPCAs, however, took advantage of reduced field operations to focus on staff training (i.e. Fiji[CS15]).

Implementation of management activities

Management plan implementation has been delayed and effective implementation reduced in many cases. Concerns for staff well-being and government public health directives meant that work involving social contact was often dropped or postponed. In the Mediterranean, 78 per cent of MPAs surveyed adopted different working arrangements with staff often working from home. Many MPAs halted field work (MedPAN, 2020). In Malaysia, where all non-essential travel was stopped, NGO staff were unable to visit MPCAs.CS11 Invasive species management was disrupted in some MPCAs: on Midway Atoll, the mice eradication programme was suspended, leaving ground-nesting seabirds vulnerable[CS1]; and invasive lionfish culling was reduced in Belize.[CS3] However, in the Galápagos, the Galápagos Biosecurity Agency, which was set up to prevent invasive species spread, converted its lab to conduct COVID-19 testing, emphasising the important role that the existence of such a biolab can play.[CS2]

The pandemic highlighted the need for MPCAs to have disaster and emergency response plans, in addition to existing ones such as those for oil spills and hurricanes. Such plans help managers decide how best to deploy resources during a crisis and minimise disruption. In the Dutch Caribbean, part of a protected area emergency response manual was rapidly adapted into a Pandemic Response Letter containing guidance for managers.[CS5]

In some cases, MPCAs with local community governance have shown greater resilience. In Fiji, the Vatu-i-Ra Conservation Park management committee resolved to maintain the traditional closure (tabu) of the park despite having no funding from tourism.[CS15] In Velondriake (Madagascar), communities decided to continue with plans to expand permanent no-take zones within the LMMA.[CS9]

Monitoring and enforcement

Ecological monitoring programmes have been affected by the pandemic in many MPCAs, as illustrated in the case studies. For example, long-term government-funded monitoring was delayed in Hawaii[CS1] and Florida.[CS4] Ecological monitoring at MPCAs supported by international volunteer programmes was disrupted in the Philippines (People and the Sea, 2020), Belize and Madagascar, although in some cases local staff are continuing monitoring efforts.[CS3,CS9,C15]

Enforcement was also affected in many MPCAs, although the pandemic had a variable impact on the need for it: in some places illegal activities decreased (e.g. where commercial fishing was disrupted) and in others they increased (see below). The GBRMPA has funded tourism operators to re-deploy their staff, once trained, to monitoring and resource management, benefiting both the park and the industry.[CS14] Budget cuts, staff capacity reduction and restrictions on movement have reduced patrolling frequency and occurrence (e.g. Mafia Island[CS8] and Nusa Penida[CS12]) as well as staff presence (e.g. Seychelles[CS10]). However, in Velondriake LMMA[CS9], in response to perceived increases in infringements, the community surveillance group stepped up its patrolling and information sharing with State-led enforcement services.[CS9]

Pandemic impacts on procedural equity

In many countries, the sudden change in national priorities – towards healthcare and the economic emergency – had an immediate impact on MPCAs. Some established MPCA decision-making processes were overridden to prioritise COVID-19 responses. Despite global calls for a green recovery and to recognise conservation as essential work, MPCAs have often

become lower priorities for government (e.g. Galápagos[CS2]). Occasionally, changed national priorities have had a positive effect. For example, the Malaysian National Security Council identified border security as a national pandemic priority, mandating that enforcement agencies prioritise this. In response, in Tun Mustapha Park – near the Malaysian border with the Philippines – coordination between enforcement agencies increased, so reducing illegal blast fishing.[CS11] Reductions in management capacity have led some MPCA authorities to devolve certain operational aspects to local communities, as in Raja Ampat, where communities were given increased autonomy to patrol and enforce rules, allowing MPA staff to focus on enforcement in more remote areas.[CS13]

Fish catch drying in the sun in a fishing village near Ampasindava, Madagascar. ©Nick Riley / WWF-Madagascar

Impacts of the pandemic on substantive effectiveness

Pandemic impacts on MPCAs that affect human well-being

MPCAs are frequently essential to the livelihoods of adjacent coastal communities who, in some countries, are among the most vulnerable and marginalised peoples (Bennett et al., 2020). In many cases, tourism has been promoted by local authorities and MPCA managers to provide alternative livelihoods, and the pandemic has highlighted the insecurity of this approach. Many of the case studies illustrate the shift from fisheries to tourism prior to the pandemic, and the consequent negative impact of the pandemic (Figure 1) on local livelihoods (e.g. Kenya[CS7], Galápagos[CS2], Tanzania[CS8] and Indonesia[CS12,CS13]). MPCA establishment is often accompanied by development of a hospitality industry involving accommodation, visitor facilities, guiding, seafood supply chains for restaurants, and water-based recreational activities. Such activities were widely halted or reduced, and many enterprises closed, as in the Mediterranean (MedPAN, 2020), Indonesia[CS12,CS13] and the Great Barrier Reef.[CS14] Attempts have been made to relaunch domestic tourism in the Great Barrier Reef[CS14] and Raja Ampat[CS13], but have had limited success principally because of pricing barriers – domestic visitors being unwilling or unable to pay the same high prices as international tourists.

The closures of some seafood markets and widespread disruption to supply chains affected numerous MPCAs. In some cases, communities increased fishing intensity or resorted to illegal practices (see section on 'environmental threats' below). Examples include the Mediterranean (MedPAN, 2020), the Pacific (Bennett et al., 2020), KenyaCS7, Madagascar[CS9], Malaysia[CS11], Indonesia[CS13] and the Great Barrier Reef.[CS14] In Velondriake LMMA[CS9], communities dependent on single supply chains (e.g. octopus fishery) have fared less well than those with more diverse income streams (e.g. sea cucumber and seaweed farming) which have provided revenue throughout the crisis.[CS9]

Pandemic impacts on environmental threats

To slow COVID-19 spread, many nations imposed travel restrictions and limited access to MPCAs (e.g. 67 per cent of Mediterranean MPCAs were closed; https://medpan.org/). This noticeably reduced disturbance from visitors, a significant threat to species and habitats in some MPCAs. Fewer cruise ships in the Florida Keys National Marine Sanctuary probably reduced noise and air pollution and sediment disturbance.[CS4] Lack of visitors led to an 18 per cent increase in water clarity in Hanauma Bay Sanctuary, Hawaii (Severino et al., 2020). Plastic pollution, however, has built up in some MPCAs which would normally be cleared by agencies supporting the tourism business.[CS6]

COVID-19 increased fishing pressure in many MPCAs. Illegal fishing by supertrawlers increased significantly in offshore MPCAs in the UK during the early months of the pandemic (Greenpeace, 2020). In many nearshore MPCAs[CS9,CS11,CS13,CS15], people who lost tourism livelihoods had to fall back on fishing, and others returned from urban areas to their coastal communities following pandemic-induced loss of employment. Lost livelihoods and uncertain food security intensified illegal extractive activities including: fishing in no-take areas (e.g. Kenya[CS7], Indonesia[CS13], Seychelles[CS10] and Australia[CS14]); replacing or even adding to legal fishing gear with destructive illegal equipment (e.g. Galápagos[CS2] and Madagascar[CS9]); and greater mangrove cutting (e.g. Madagascar[CS9]). MPCA compliance during the pandemic in some cases, such as Gokova Bay,

A split-level view of a shallow coral reef and house on stilts in North Raja Ampat, West Papua, Indonesia ©Jürgen Freund / WWF

Turkey, depended on location, with increased illegal fishing in more rural areas, but regulations nearer urban areas continuing to be respected (MPA News, 2020a). For some MPCAs, both inshore and offshore, however, the overall reduction in commercial fishing that has been documented for several countries and regions (Clavelle, 2020; FAO, 2020), may have led to reduced incursions, although documentation is scarce.

Potential new threats to MPCA biodiversity emerged in some places during the pandemic. Increased farming next to or within MPCAs (e.g. Raja Ampat[CS13]) and expanded aquaculture activities within MPCAs (e.g. Nusa Penida[CS12]) have offered livelihood opportunities in the absence of tourism; but, when not managed, both can cause pollution.

Pandemic impacts on biodiversity and resource condition

Anecdotal reports and some initial studies suggest variable ecological responses within MPCAs due to the pandemic. In some cases, species have increased in abundance or their distribution has changed, presumably due to reduced human disturbance; for example, nesting areas of Kentish Plover (*Charadrius alexandrinus*) on the Italian Adriatic coast expanded[CS6]; marine mammal and large fish sightings increased near to shore in Galápagos[CS2], Hawaii (Severino et al., 2020) and Raja Ampat[CS13]; manta rays appeared less wary in Nusa Penida[CS12]; and sea turtle nesting on beaches in Kenya increased.[CS7]

Negative effects on biodiversity may become apparent as monitoring activities resume post-pandemic. Increased fisheries pressure within MPCAs may exceed sustainable levels. Reduced access to, and tourism in, MPCAs may also have perverse biodiversity outcomes. In Kenya, a curfew limited fishing to nearshore areas and led to more trampling of corals.[CS7] While plastic pollution build-up on beaches in Adriatic MPCAs may have hindered turtle nesting, the reduced disturbance from cleaning actually benefited nesting birds.[CS6]

Pandemic impacts on substantive equity

Stakeholders and communities dependent on MPCAs have been affected in different ways by COVID-19 (Figure 1). Greatest impacts have been felt by those

reliant on tourism, as well as fishers reliant on MPCAs. For example, Malaysian fishers were uncertain whether continued fishing breached government movement restrictions that would be enforced by park authorities, thus undermining fisher food security.[CS11] Declines in fish prices or closures of markets have forced some fishing communities into bartering to maintain food security.[CS2,CS11] In Raja Ampat, the pandemic has disproportionately affected fishers in more remote parts of the archipelago as transport connections to the main fish markets are reduced.[CS13] Pandemic restrictions have particularly affected women: traditionally, women sell fish in the evenings in Kenya, but they have been disproportionately affected by a curfew (Kithia et al., 2020).[CS7]

MPCAS POST-COVID-19—'BUILDING BACK BETTER'

The case studies show at least five main areas where MPCAs illustrate either vulnerability or resilience to the pandemic: (1) sustainable financing, (2) devolved and equitable management, (3) seafood supply chains, (4) adaptive MPCA monitoring and enforcement, and (5) communications capacity. For each of these five areas, we look at the opportunities for learning from the experience of the pandemic and thus ensuring more effective management in the future, with a notable emphasis on the increasing role of emerging and applied technology.

Sustainable financing

MPCAs were underfunded before the pandemic (Meyers et al., 2020), and highly vulnerable to global recessions and disruption of tourism. MPCAs often have higher financial needs than terrestrial sites, since enforcement, monitoring and research are logistically more complex in the marine environment, requiring boats, specialised equipment and particular expertise (Bohorquez et al., 2019). Efforts to diversify MPCA financing must accelerate, whilst ensuring that revenue generated contributes to on-going operations as well as short-term project needs. Financing mechanisms need to be resilient to stress events, like pandemics, climate change and financial crises. Further trialling and documentation of funding models are needed. Trust funds have often proved successful but those established for some MPCAs[CS13,CS10] were unable to respond to budget shortfalls as they are designed to support project-based activities rather than operating costs. However, in the Dutch Caribbean, the Nature Conservation Trust Fund can provide emergency funding, and each protected area received an additional US$ 150,000 this year.[CS5]

User fees (e.g. visitor entry, diving and other in-water activities, guided tours, food outlets) have been an easy option for generating revenue for both communities and MPCA management authorities. During the pandemic, some MPCAs were able to generate revenue from local tourism when international tourism ceased, and in some cases the sale of entry tickets and souvenirs was brought online[CS6], an approach that could be retained post-pandemic. Virtual tourism may expand in the future, allowing overseas 'visitors' to maintain support for an MPCA. Multiple modalities exist for this, but it will be necessary to add value beyond videos and photographs, providing for example, virtual dives and fundraising opportunities (Guttentag, 2010; Jung and Claudia tom Dieck, 2018).

Numerous options for financing exist beyond tourism. The Blue Finance programme (http://blue-finance.org) focuses on impact investors – that is, investors who seek positive environmental and social outcomes through their investments – using a model involving co-managed MPCAs: trials are underway in the Caribbean and South-East Asia. Crowdfunding was used for management activities in Seychelles before the pandemic (Shah, 2017), and in Malaysia during the pandemic where communities in Tun Mustapha Park used this to obtain food.[CS11] The sale of carbon offset credits is an established financing mechanism for terrestrial protected and conserved areas and is now being applied to marine conservation (Howard et al., 2017; MPA News, 2020b), with multiple initiatives underway to integrate 'blue carbon' credits (from protection and restoration of mangroves, salt marshes and seagrass) into MPCAs (Moraes, 2019). Examples include Velondriake LMMA, where demand for Tahiry Honko carbon credits pre-pandemic outstripped supply[CS9]; and Nature Seychelles, which buys carbon credits to make Cousin Island Special Reserve carbon neutral.[CS10] Despite challenges ahead (Howard et al., 2017) and concerns about potential unintended consequences of off-setting (MPA News, 2020c), the aviation and tourism industries provided most demand for carbon credits pre-pandemic (Gross, 2020).[CS9] The protection of blue carbon stocks features in many nations' nationally determined contributions to the United Nations Framework Convention on Climate Change, and may thus provide further leverage for funding for MPCAs (Gallo et al., 2017).

In the current environment, any additional funding for MPCAs or other ocean and/or conservation initiatives will help improve outcomes and effective management of MPCAs. From the case studies we have observed, the one critical constraint is the ability of suppliers and

buyers of blue carbon to meet and transact inexpensively. This bottleneck can be addressed through the creation of a secure and more easily accessible marketplace for carbon that leverages existing technology. This approach has already been demonstrated by the REDD+ initiative (Robinson, 2018) which utilises blockchain functionality to facilitate similar outcomes that can be used for MPCAs. As blockchain is still a new technology, there is a natural gap in knowledge between technological enthusiasts and natural resource managers as well as policy makers. A technical understanding is not essential for the purposes of this paper, but UNDP (2020) provides a succinct description of how blockchain is relevant for reaching the SDG goals.

Reducing funding requirements is as important as raising revenue. Costs can be much reduced by giving communities responsibility for management in exchange for secure access to resources. In Belize, the integration of MPCA and fisheries management through the Managed Access Program has given licensed fishers greater involvement in management of MPCAs, through monitoring of their catches and representation on Managed Access Committees, in exchange for rights to catch a controlled portion of fisheries stocks in the general use zones of some MPCAs (Martinez et al., 2018). Microfinance, such as community-led savings and loans schemes, have been set up alongside community-managed MPCAs in many places such as MadagascarCS9, the Philippines (Garcia, 2018), Kenya and Tanzania (Nicholas, 2019). These allow people to save money and access credit in exchange for playing an active role in management of the area. Such schemes have provided vital financial support during the pandemic and could be scaled up to ensure more resilient financial systems in future.

Young mangrove plants along the northern shoreline of Mali Island, Vanua Levu, Fiji ©Tom Vierus / WWF-US

Devolved and equitable management

Building back post-COVID-19 will require coordinated actions across multiple scales. The case studies show that in many places, communities and community-based or co-managed governance systems have some resilience and capacity to adapt (Folke et al., 2002) to unexpected circumstances such as the pandemic. For example, the loss of international tourism and its associated revenue in the Galápagos led to the emergence of new commerce enabled by local production and trade.[CS2] MPCAs with strong local community governance structures in place were often better placed to weather the crisis and secure support from partner organisations and governmental services.[CS9] Several case studies show an increase in harmful fishing practices in response to economic and food insecurity caused by the pandemic. Ensuring that governance systems can withstand an increasingly uncertain future requires building on the momentum started pre-COVID-19 to mainstream equity and benefit sharing in MPCAs. Empowering and reinforcing local institutions to lead on MPCA management is vital.[CS7, C15]

Improving the efficiency of seafood supply chains

The resilience and sustainability of seafood supply chains are inextricably linked to their governance and the technology available. Supply chains were affected globally during the pandemic, with direct impacts on those who rely on trading marine resources for income, particularly where single source supply chains were involved. In some cases, modern communications infrastructure provided solutions; for example, fishers operating in and around MPCAs at Telascica and Lastovo Islands (Croatia), Tun Mustapha Park (Malaysia) and Raja Ampat found it difficult to get fish to market – with physical markets often closed or supply chains disrupted.[CS6,CS11,CS13] As a result, ad hoc virtual markets on Facebook were set up to connect fishers and fish traders directly with consumers – a solution that could be scaled up elsewhere. This is an example of how technology can provide tangible new solutions to building the resilience of MPCAs and those who depend on them.

There is already a broad literature on supply chain resilience (Golan et al., 2020), and sustainable supply chains (Zavala-Alcívar et al., 2020) outlined as relevant for achieving the SDGs. Blockchain technology has been identified as a useful tool for achieving sustainability goals (Adams et al., 2018; UNDP, 2020) and can help address multiple emerging supply chain issues (Howson, 2020). Blockchain based marketplaces can

give fishers low cost direct access to local and international markets and bypass the challenge of matching local demand for, and supply of marine products. For example, by-catch or parts of the fish typically seen as waste products can be sold, and this has already been explored through initiatives such as WWF-Australia's collaboration with OpenSC (WWF-Australia, 2020).

These initiatives demonstrate that blockchain technology can be used effectively to track the source of marine products, from line to plate, giving consumers more sustainable choices (Howson, 2020). Implemented in parallel with existing MPCA programme goals, blockchain can be a mechanism to lower costs of governance, monitoring and oversight while also enhancing fishers' businesses and community outcomes.

Monitoring and enforcement

Budget cuts and public health directives as a result of the pandemic have had a significant impact on certain MPCA activities, in particular research, monitoring and enforcement. Programmes that rely heavily on data collection by individuals or groups living outside MPCAs and their adjacent communities were badly impacted. There are several emerging technologies that can help to mitigate this. For example, mobile software[2], can be used to collect and analyse locally-collected data, which can support the kind of informed, rapid decision-making that is vital in a crisis while developing local monitoring capacity. Platforms are also improving rapidly for the remote collection and analysis of ship-borne tracking and monitoring data – including automatic identification system (AIS) and vessel monitoring systems[3] – and for integrating those data with satellite-based synthetic aperture radar and multispectral data. Where expensive and complex AIS and VMS systems are not feasible, as in tracking small-scale fishing, simple self-contained systems are becoming available[4] which also reduce requirements for individuals on site.

Satellite-based remote sensing, which allows the collection of data over large areas and at large volumes, is often freely available (e.g. Sentinel-2, Landsat 8) on open platforms that facilitate analysis (e.g. Google Earth Engine), and will play a key role in monitoring and enforcement in future. This technology makes it possible to map and monitor changes in important coastal habitats, such as mangroves (e.g. Global Mangrove Watch) and coral reefs (e.g. Allen Coral Atlas). Autonomous (e.g. https://www.saildrone.com/) and remotely operated vehicles are another means of

Woman walking in Mafia Island Marine Park, Tanzania ©Doris Calegari / WWF-Switzerland

data collection and surveillance, and are becoming more affordable (Jiménez López & Mulero-Pázmány, 2019). Such technology reduces the need for teams on the ground, a major asset in crises such as a pandemic. There will, nevertheless, be a continued need to build capacity for locally based monitoring, such as in Velondriake LMMA[CS9]; this is essential for ground-truthing, but also provides employment and opportunities to engage local communities in park management. There is a level of technical sophistication necessary for analysis of the vast amount of data produced by drone cameras and other sensors, and so investment in capacity development is urgently needed to accelerate the use of these technologies in MPCAs.

Robust monitoring will not be enough on its own: greater attention was already being paid pre-pandemic to the need to embed the monitoring and assessment of MPCAs in management systems. The pandemic has demonstrated the need to ensure that social, economic and ecological monitoring is underpinned by user-

friendly, robust and adaptive systems for data collection, storage and analysis and also that it is designed to be sustainable (and informative) in crises situations. This will involve the use of the newest technology and ensuring that the data collected will help MPCA decision-makers to identify risks from climate change, pandemics and other major events[5].

Communications, coordination and collaboration capacity

A good communications infrastructure is critical to the resilience of MPCAs. In the Adriatic SeaCS6, the pandemic situation led to mobile and virtual communication technology being used extensively which improved the transparency and effectiveness of collaboration between MPCA practitioners, and will be retained in the future. Well-prepared and informed online meetings and email exchanges can lead to more objective discussion than physical in-person meetings, and often make it easier to track what was said, when and by whom. In addition, the Adriatic Protected Areas Network (AdriaPAN), which enabled collective reflection and sharing around preparations for a second lockdown, demonstrated the value of such social MPCA networking systems, many of which were being established pre-pandemic in different regions.[CS6]

Reliance on technology for virtual meetings and remote education also demonstrated the potential for the wider adoption of these tools for public engagement in remote or large-scale MPCAs (e.g. Hawaii[CS1], Florida[CS4] and the Great Barrier Reef[CS14]). However, in some countries, MPCAs may not have the 'economic density' for mobile network operators to invest in coverage (Cherry, 2003), making it difficult to achieve the kind of virtual collaboration and learning seen in the Adriatic Sea, USA and Australia. Nevertheless, Community Cellular Networks – low cost cellular radios managed locally by a community – have been deployed in Mexico, Philippines and Indonesia (e.g. Keleher et al., 2020), and provide the means by which experiences and learning can be shared. Such systems may also be used for income generation, for example, marketing fish (Ali & Heimerl, 2018).

CONCLUSION

Recalling Heraclitus's wisdom, "there is nothing permanent except change", we argue that management of MPCAs needs to be adaptive to change in order to support nature and people, as demonstrated by the diversity of challenges as well as responses in the management of MPCAs during the pandemic. Extended exposure to major disturbance requires that more attention be given to resilience, and needs meaningful integration with, and attention to, the social, cultural, political and economic context of each site. The recent zoonotic disease outbreaks show how fundamentally broken human relationships have become with nature (IPBES, 2020). Yet COVID-19 has opened a window of opportunity for us to rethink and rebuild these relationships, and create MPCAs that are locally and collaboratively driven, and supported by innovative technologies, tools and ethical financing mechanisms. Such a transformation is essential if SDG 14 is to be achieved.

The length and the severity of disruption caused by the pandemic remains unclear, but efforts should be made to make MPCA management and governance more ethical and effective, putting the principles of equity and resilience at the forefront of 'building back better' (Leach et al., 2020). This means building on successes and ensuring that enabling conditions exist for grassroot adaptations. MPCAs must be designed and managed in such a way that social-ecological resilience is fostered. This will involve maintaining diversity and redundancy in systems, managing connectivity, ensuring adaptive system thinking, encouraging learning and broadening participation (see the seven principles of resilience outlined in Biggs et al., 2015). Similar recommendations for improving ocean resilience as a whole, post-pandemic, have been made by the High-Level Panel for a Sustainable Ocean Economy (Northrop et al., 2020), the World Economic Forum through its Virtual Ocean Dialogues (https://www.weforum.org/events/virtual-ocean-dialogues-2020) and others, such as Laffoley et al. (2020a; 2020b).

Strategies to improve the outcomes for MPCAs should support the people living in or near them – and vice versa. The pandemic, climate change and other rapidly growing pressures require that we strengthen synergies between conservation and resilient livelihoods, addressing the challenges of sustainable development in a more tangible way. Our case studies confirm the importance of building social-ecological resilience. We should learn this and other lessons from the pandemic, applying innovation in our efforts to safeguard the future of marine ecosystems and the people that depend on them, and manage better for uncertainty. One mechanism to do so could be through the establishment of an MPCA Futures Working Group, under the umbrella of the IUCN World Commission on Protected Areas' 'Protected Areas & COVID Task Force'.

To achieve these changes and facilitate cross-learning and innovation, conservationists need to break down

silos and work closely with diverse stakeholders and experts from beyond the MPCA community. Rebuilding a better future will depend on this.

ENDNOTES

[1]The term '"blockchain'" refers to the technology itself. It forms an immutable record of the transactions for all users, so that no external authority is needed to validate the authenticity and integrity of the data. It can be used with any kind of data and can facilitate direct transfer of asset ownership.

[2]SMART# (https://smartconservationtools.org/ –- used widely for MPCA enforcement), Open Data Kit (https://opendatakit.org/ –- software that allows for offline data collection with mobile phones –- e.g., Jeffers et al., 2019), and MERMAID software (https://datamermaid.org/ –- used for gathering and aggregating data from coral reef surveys).

[3](VMS; https://globalfishingwatch.org/; https://www.oceanmind.global/; https://vulcan.com/skylight)

[4]e.g. https://www.pelagicdata.com/

[5]Since 2006, MPCAs in the Dutch Caribbean have been using an assessment tool (Management Success) based on IUCN's framework for assessing management effectiveness, and this will be used to track the impact of the pandemic and the shortfalls it has created, in the same way that it previously addressed other crises such as hurricanes.[CS5]

SUPPLEMENTARY ONLINE MATERIAL

Marine case studies compilation - CS1 to CS15

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RESUMEN

La intersección de los posibles objetivos y compromisos mundiales establecidos para la conservación de los océanos con la pandemia del COVID-19 en 2020, ha permitido reconsiderar el futuro de los instrumentos de conservación basados en las áreas marinas, en particular para las áreas marinas protegidas y conservadas (AMPC). Dado que las AMPC continúan prestando servicios ecológicos, sociales y económicos esenciales, los enfoques actuales para establecer y gestionar estas áreas requieren una comprensión de los factores que impulsan las presiones a las que se enfrentan. Examinamos brevemente su estado prepandémico y ofrecemos una visión general de los impactos del COVID-19 mediante la presentación de 15 estudios de caso. Los impactos son de dos tipos: los que afectan los medios de vida y el bienestar de las comunidades locales y los interesados directos que dependen de las AMPC; y los que afectan la gestión y gobernanza de las AMPC. Las respuestas de los administradores y las comunidades han abordado: la gestión de los recursos; los ingresos y la seguridad alimentaria; la vigilancia y la aplicación de la ley; las cadenas de suministro de alimentos de origen marino; y la comunicación entre los administradores, los miembros de la comunidad y otras partes interesadas. Por último, examinamos las herramientas y enfoques innovadores para la ampliación y el cambio transformacional, haciendo hincapié en las sinergias entre la gestión para la conservación y la gestión de los medios de vida sostenibles, y su relación con los principios de equidad y resiliencia.

RÉSUMÉ

La rencontre en 2020 entre les objectifs et les engagements mondiaux pour la conservation des océans et la pandémie de COVID-19 a permis de repenser l'avenir des outils de conservation marine, en particulier pour les aires marines protégées et conservées (AMP). Dès lors que les AMP continuent de fournir des services écologiques, sociaux et économiques essentiels, il est crucial que les approches actuelles pour les créer et les gérer tiennent compte des facteurs de pression qu'elles subissent. Nous passons brièvement en revue leur état avant la pandémie et fournissons un aperçu des impacts de la COVID-19 à travers 15 études de cas. Les impacts sont de deux types: ceux qui touchent aux moyens de subsistance et au bien-être des communautés locales et des parties prenantes qui dépendent de l'AMP, et ceux qui concernent la gestion et la gouvernance de l'AMP elle-même. Les réponses des communautés et des gestionnaires ont porté sur la gestion des ressources, le revenu et la sécurité alimentaire, la surveillance et le contrôle, les chaînes d'approvisionnement des produits de la mer, et la communication entre les gestionnaires, les membres de la communauté et les autres parties prenantes. Pour conclure, nous discutons d'approches et d'outils innovants d'analyse et de changement transformationnel, en mettant l'accent sur les synergies entre la gestion de la conservation et la gestion des moyens de subsistance durables, et comment celles-ci sont liées aux principes d'équité et de résilience.