frontiers | Frontiers in Marine Science

TYPE Brief Research Report
PUBLISHED 03 October 2022
DOI 10.3389/fmars.2022.1012815

OPEN ACCESS

EDITED BY
Carolyn J. Lundquist,
National Institute of Water and Atmospheric Research (NIWA), New Zealand

REVIEWED BY
Sarah Annalise Gignoux-Wolfsohn,
Smithsonian Environmental Research Center (SI), United States
Dawn Kotowicz,
United States Geological Survey (USGS), United States

*CORRESPONDENCE
Steven Mana'oakamai Johnson
steven.johnson@cornell.edu

SPECIALTY SECTION
This article was submitted to Marine Conservation and Sustainability, a section of the journal Frontiers in Marine Science

RECEIVED 05 August 2022
ACCEPTED 16 September 2022
PUBLISHED 03 October 2022

CITATION
Mana'oakamai Johnson S and Villagomez AO (2022) Assessing the quantity and quality of marine protected areas in the Mariana Islands. *Front. Mar. Sci.* 9:1012815. doi: 10.3389/fmars.2022.1012815

Assessing the quantity and quality of marine protected areas in the Mariana Islands

Steven Mana'oakamai Johnson[1,2*] and Angelo O. Villagomez[3]

[1]Department of Natural Resources and the Environment, Cornell University, Ithaca, NY, United States, [2]Tåno, Tâsi yan Todu, Hagatña, GU, United States, [3]Center for American Progress, Washington, DC, United States

Marine protected areas (MPAs) are ubiquitous in global ocean conservation and play a pivotal role in achieving local, national, and regional area-based conservation targets. Often, such targets are merely met on "paper" and lack the political or managerial resources to produce positive conservation outcomes. Here, we apply the MPA Guide – a framework for assessing the quantity and quality of marine protected areas – to Guam and the Commonwealth of the Northern Mariana Islands (CNMI), two U.S. territories in the Western Pacific. We reviewed the enabling legislation and applicable management documents for all MPAs (n=18). We found that all but three (3) MPAs in the Mariana Islands are actively managed, and these areas are either fully or highly protected – the highest tier of the MPA Guide. Lightly protected areas are associated with high use/high-density tourism activities. Total area protected varies at the jurisdictional scale: 0.83% of Guam's territorial waters (out to 12 nm) and 23.73% of EEZ under some spatial management; CNMI has 20.39% of territorial waters and 25.91% of EEZ in MPAs. These results emphasize the importance of quality, quantity, and scale when determining effective conservation, especially in overlapping and contested jurisdictional authority areas.

KEYWORDS

marine protected areas, marine conservation, Mariana Islands, assessment, 30x30

1 Introduction

The United Nations (U.N.) declared this decade (2021 to 2030) as the U.N. Decade of Ocean Science for Sustainable Development, which "will provide a common framework to ensure that ocean science can fully support countries' actions to sustainably manage the Oceans and more particularly to achieve the 2030 Agenda for Sustainable Development." This global initiative is one of the many layers of marine conservation aimed at fostering social-ecological synergies (Claudet et al., 2020). Regional efforts such as the Micronesia Challenge (The Micronesia Challenge, 2006) and the Coral Triangle

Initiative (Coral Triangle Initiative, 2009) have been attempting to tie environmental health to social and economic goals since 2006 and 2009, respectively, with early signs of success across a range of indicators (Cuetos-Bueno, 2012; Beger et al., 2015; Montambault et al., 2015). Additionally, by linking local and national conservation efforts together, such as the America the Beautiful Initiative, regional and international coordination can make conservation more cost-effective (Kark et al., 2009), with a greater likelihood of success (Roberson et al., 2021).

Proper conservation and management tools are central to achieving these linked social-environmental goals. Marine protected areas (MPAs) are spatial marine conservation tools that regulate the number and types of human activities allowed in a given ocean area (Gubbay, 1995). Currently, there are over 16,800 MPAs across the globe, ranging in size from less than 1 km to over 2 million km2, covering 7.93% of the ocean (UNEP-WCMC and IUCN, 2022). MPAs have shown demonstrable benefits across multiple scales in social, economic, and environmental sectors (Beger et al., 2015; Marcos et al., 2021) and, importantly, complement many of the traditional management practices of Indigenous peoples (Gaymer et al., 2014; Friedlander, 2018). Despite the widespread and continued adoption of MPAs, the level of protection afforded by MPAs are quite variable, with some MPAs allowing industrial fishing and other activities incompatible with the conservation of nature (Zupan et al., 2018), while others are "paper parks" – protected areas designated without active management (Di Minin and Toivonen, 2015).

Reduced MPA performance has been driven primarily by shortcomings in staffing (direct resource management and enforcement) and funding (Gill et al., 2017). Poor MPA design and lack of implementation create two challenges for effective marine conservation: 1) they allow local, state, and national governments to artificially reach area-based targets of conservation without actually protecting the ocean (Singleton and Roberts 2014) and, 2) inadequate protection of the ocean makes achieving development targets such as the Sustainable Development Goals (SDGs) and climate goals increasingly difficult (Roberts et al., 2017; Reimer et al., 2020). For island nations and territories, effective protection is critical for long-term sustainability in the face of shifting geopolitics and climate change (Gruby, 2017; Asch et al., 2018). For these significant social and environmental investments to pay dividends in the future, the quality and context of protection need to be understood. Given the dire prognosis of future environmental conditions within MPAs due to climate change (Bruno et al., 2018; Johnson and Watson, 2021), quality protection within the proper social-political context is necessary for securing sustainable ocean futures (Bennett et al., 2021).

Here, we assess progress towards effective marine conservation goals in Guam and the Commonwealth of the Northern Mariana Islands (CNMI), the two U.S. territories in the Mariana Islands Archipelago. Additionally, both territories are participants of the Micronesia Challenge, a regional conservation initiative to effectively conserve 50% of marine resources by 2030 – an increase from the original goal of 30% by 2020 (The Micronesia Challenge, 2006). Current estimates of effective marine conservation in the Marianas are based solely on the stated area protected, with a dearth of information on the quality – both in terms of the level of protection and stage of implementation. We address this knowledge gap by assessing MPAs in the Mariana Islands using the framework outlined in the MPA Guide (Grorud-Colvert et al., 2021; see section 2.2 for details of) and discuss management options for achieving stated conservation goals.

2 Materials and methods

2.1 Mariana Islands (Guam and the CNMI)

The Mariana Islands are located in the tropical North Pacific Ocean, consisting of 15 volcanic and raised limestone islands (Figure 1). The Marianas are divided into two territories of the United States: the territory of Guam and the Commonwealth of the Northern Mariana Islands (CNMI), which includes all of the Mariana Islands other than Guam. Combined, the Marianas covers an oceanic area of 971,860.57 km^2 (Guam: 208,234.15 km^2; CNMI: 763,626.42 km^2) and a total population of 201,165, primarily concentrated on Guam (153,836) (Guam Bureau of Statistics and Plans, 2021) and Saipan (43,385) (US Census Bureau, 2021). The Marianas are the homelands of the CHamoru/Chamorro people, who settled the archipelago 3.5-4.3k ybp (Athens et al., 2004; Carson, 2020), and the Refaluwasch, originally from the Caroline Islands of Satawal, who arrived during the 19th century (Flood, 2001). Both Indigenous groups use various fishing methods and practices based on traditional ecological knowledge and customary practices (Johannes, 1978). Today, fishing in the Mariana Islands predominantly focuses on nearshore coral reef species (Cuetos-Bueno and Houk, 2014; Houk et al., 2018) and a small-boat fleet for pelagic and bottom fish species (WPRFMC, 2021). Coral reefs in the CNMI and Guam are valued at US$61.16 million and US$127 million per year, respectively, primarily driven by tourism and ecosystem services (van Beukering et al., 2006; van Beukering et al., 2007).

Governance of marine resources in the Marianas is a complex layer of territorial and jurisdictional claims that emerged from social and political activism to reclaim ownership from the U.S. federal government (Gruby, 2017). Guam became an unincorporated, organized territory of the United States following the Guam Organic Act of 1950, which gave the Secretary of the Interior administrative responsibility for the island. The CNMI transitioned from a post-World War II Trust Territory of the United States to a self-governing entity under the sovereignty of the U.S. following the 1976 Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America (Public Law 94-241, 1976). In 1974, the U.S. Congress

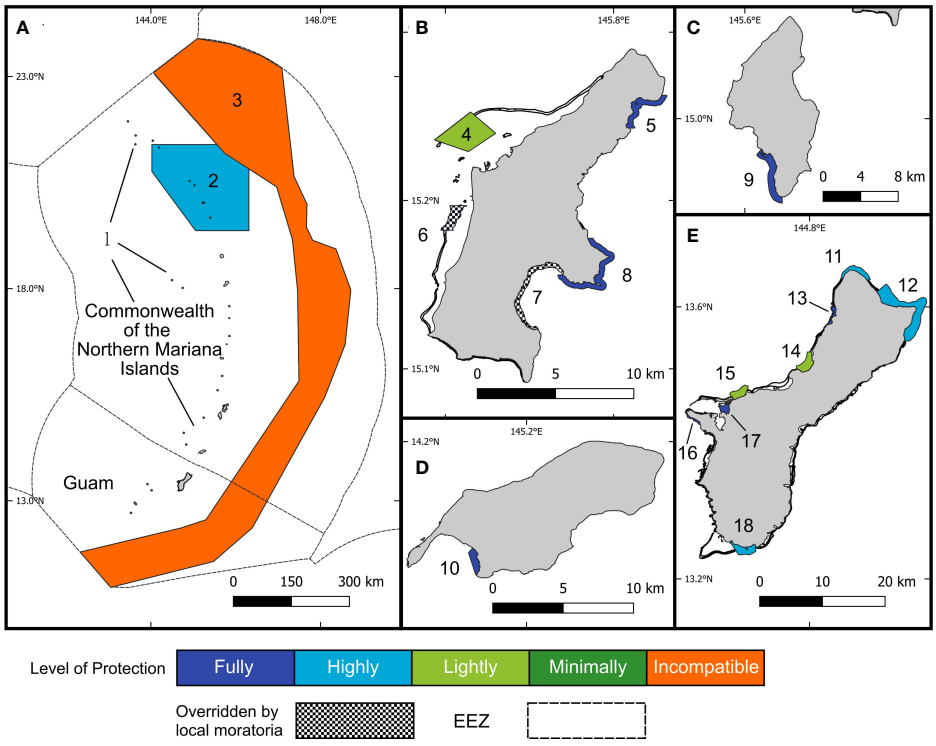

FIGURE 1
Map of spatial marine conservation in the Mariana Islands. **(A)** The Mariana Trench Marine National Monument and National Wildlife Refuge units extend across both territorial exclusive economic zones (EEZ). **(B–E)** Maps of spatial marine conservation areas on Saipan, Tinian, Rota, and Guam, respectively. Numbers refer to site names found in Table 1.

passed the Territorial Submerged Lands Act, which gave Guam jurisdiction over submerged lands extending three nautical miles. In 2004, the CNMI sued the U.S. in District Court, asserting its claim of jurisdiction over ocean submerged lands and marine resources from its coastline to 200 nautical miles. The District Court ruled that the U.S. has "paramount authority over those lands and resources as necessary and retained elements of its national sovereignty." The decision was appealed, but the Ninth Circuit affirmed the District Court's ruling; however, it recognized that Congress has the authority to transfer ownership of submerged lands. In 2014, President Barack Obama signed Public Law 113-34, conveying submerged lands around 9 of the 14 CNMI islands out to three nautical miles. In 2016, submerged lands out to three nautical miles around an additional three islands were conveyed to the CNMI. The territorial waters of each territory extend from shore out to 12 nautical miles (controlled by the federal government, except as outlined above). The Exclusive Economic Zone (EEZ) extends from 12 to 200 nautical miles. These diverging paths toward governance present opportunities and challenges for ocean conservation and fisheries management within and across the two jurisdictions (Cuetos-Bueno et al., 2018; Houk et al., 2018).

2.2 Assessing protection – the MPA guide

To quantify the quantity and quality of marine protection in the Marianas, we implemented the framework presented in the MPA Guide (Grorud-Colvert et al., 2021). The MPA Guide outlines a science-based and policy-relevant framework that evaluates the stage of establishment, the level of protection, and the enabling socio-political conditions to determine the likely outcomes of a given MPA. Stage of establishment determines an MPAs status in the process of creating an MPA. Categories include *Proposed/Committed*, *Designated*, *Implemented*, and *Actively Managed*. Each category is defined by a minimum criteria and best practices (Table S1). Level of protection determines the types, numbers, and intensity of activities allowed within an MPA. These levels include *Minimally Protected*, *Lightly Protected*, *Highly Protected*, and *Fully Protected* (Table S1). Certain activities are prohibited in all levels (e.g., mining activities), while others are permissible in all levels, but at varying intensities (e.g., non-extractive activities such as tourism). Conservation areas that fail to meet the

minimum criteria may be considered *Incompatible with the Conservation of Nature*. Enabling conditions are the social and political characteristics that allow MPAs to achieve their goals. These include whether an MPA is "effectively planned, designed, implemented, governed, and managed" (Grorud-Colvert et al., 2021; Table S1).

For each MPA in the Marianas, we obtained the most recent management plan and enabling legislation for the area to determine the stage and protection level (Table 1). Additionally, we reviewed local and federal laws that either augment or supersede the regulation of the MPA, as these could either strengthen, weaken, or negate the protection

TABLE 1 List of marine protected areas in the Mariana Islands.

Jurisdiction	Site (number)	Year est.	Area (km^2)	Management Authority	STAGE	LEVEL	Ref.
Guam + CNMI	Marianas Trench MNM – Arc of Fire National Wildlife Refuge (1)	2009	189.03	US Department of Interior and U.S. Department of Commerce	Designated	Incompatible with the Conservation of Nature	NOAA Fisheries, 2013; Marianas Trench Marine National Monument, 2020
	Marianas Trench MNM – Island Unit (2)	2009	42,530.02	US Department of Interior and U.S. Department of Commerce	Designated	Highly Protected	
	Marianas Trench MNM – Mariana Trench National Wildlife Refuge (3)	2009	204,537.44	US Department of Interior and U.S. Department of Commerce	Designated	Incompatible with the Conservation of Nature	
Commonwealth of the Northern Mariana Islands	Mañagaha Marine Conservation Area (4)	2000	5.03	CNMI Division of Fish & Wildlife	Actively Managed	Lightly Protected	Mañagaha Marine Conservation Act, 2000; Schroer, 2005
	Bird Island Marine Sanctuary (5)	2000	1.46	CNMI Division of Fish & Wildlife	Actively Managed	Fully Protected	Public Law 12-46, 2001
	Lighthouse Reef Trochus Sanctuary (6)	2000	1.10	CNMI Division of Fish & Wildlife	Actively Managed	Overridden by Local Moratoria	CNMI Administrative Code §85-30.1-420
	Laolao Bay Sea Cucumber Sanctuary (7)	2000	1.96	CNMI Division of Fish & Wildlife	Actively Managed	Overridden by Local Moratoria	CNMI Administrative Code §85-30.1-420; Public Law 11-63, 2000
	Forbidden Island Marine Sanctuary (8)	2000	2.52	CNMI Division of Fish & Wildlife	Actively Managed	Fully Protected	Public Law 12-46, 2001
	Tinian Marine Reserve (9)	2007*	4.57	CNMI Division of Fish & Wildlife	Actively Managed	Fully Protected	Public Law 15-90, 2007; Public Law 17-14, 2010
	Sasanhaya Bay Fish Reserve (10)	1994	0.84	CNMI Division of Fish & Wildlife	Actively Managed	Fully Protected	Rota Local Law 9-2, 1994
Guam	Guam National Wildlife Refuge (11)	1993	3.36	US Fish & Wildlife Service	Actively Managed	Highly Protected	
	Pati Point Marine Reserve (12)	1997	19.79	Guam Division of Aquatic & Wildlife Resources	Actively Managed	Highly Protected	Public Law 24-14, 1997
	Haputo Ecological Reserve (13)	1984	0.64	US Fish & Wildlife Service	Actively Managed	Fully Protected	SWCA Environmental Consultants, 2010a
	Tumon Bay Marine Reserve (14)	1997	4.51	Guam Division of Aquatic & Wildlife Resources	Actively Managed	Lightly Protected	Public Law 24-14, 1997
	Piti Bomb Holes Marine Reserve (15)	1997	3.55	Guam Division of Aquatic & Wildlife Resources	Actively Managed	Lightly Protected	Public Law 24-14, 1997
	Orote Ecological Reserve (16)	1984	0.67	US Fish & Wildlife Service	Actively Managed	Fully Protected	SWCA Environmental Consultants, 2010b
	Sasa Bay Marine Reserve (17)	1997	1.78	Guam Division of Aquatic & Wildlife Resources	Actively Managed	Fully Protected	Public Law 24-14, 1997
	Achang Reef Flat Marine Reserve (18)	1997	4.54	Guam Division of Aquatic & Wildlife Resources	Actively Managed	Highly Protected	Public Law 24-14, 1997

afforded by the MPA (Albrecht et al., 2021). After classifying all MPAs using the MPA Guide, we calculated the total area in each jurisdiction under a given combination of stage of establishment and level of protection, answering "how much" and "what kind of" protection exists in the region. Spatial calculations were conducted in R using the sp package.

3 Results

3.1 Quantity of area-based marine conservation in the Marianas

The Mariana Islands have 18 MPAs with some level of restriction on the harvest of marine resources, encompassing 247,312.81 km2 (Guam: 49,403.69 km^2; CNMI: 197,847.80 km^2; Figure 1). These areas range from 0.64 – 204,537.44 km^2 (Table 1). Guam has 0.83% of territorial waters (out to 12 nm) and 23.73% of EEZ under some spatial management. The CNMI has 20.39% of territorial waters and 25.91% of EEZ under some spatial management. The Mariana Trench Marine National Monument (MTMNM), which encompasses 247,256.49 km^2 across three management units (Islands Unit, Mariana Trench National Wildlife Refuge, and Mariana Arc of Fire National Wildlife Refuge), is responsible for the vast majority of spatial conservation in the two jurisdictions (Guam: 99.80%; CNMI: 99.97%).

3.2 Quality of area-based ocean conservation in the Marianas

3.2.1 Stage of establishment

MPAs in the Mariana Islands are in two stages of establishment: Designated and Actively Managed. The majority of MPAs fall into the latter category (n=15). The first MPAs in the Mariana Islands were established in 1984 (the Haputo and Orote Point Ecological Reserves) by the U.S. Fish & Wildlife Service (USFWS). Subsequently, the Guam National Wildlife Refuge was established by USFWS in 1993, followed by the five MPAs administered by the local Guam government in 1997. The CNMI's first MPA was the Sasanhaya Fish Reserve on the Island of Rota, established in 1994. A series of legislative activities from 1999-2001 established three MPAs on Saipan and two species-specific reserves (sea cucumber and Trochus top shell, respectively). The Tinian Marine Reserve was established in 2007 and, in 2010, was downsized due to the prospect of increased U.S. Department of Defense activities on the island that could reduce local access to traditional fishing grounds. The MTMNM was established in 2009 under the U.S. Antiquities Act by President George W. Bush. The three units of the MTMNM are currently classified as Designated (management plan under public review at the time of writing, (Marianas Trench Marine National Monument, 2020)).

3.2.2 Level of protection

MPAs located in the territorial waters of the Mariana Islands exhibit a range of levels of protection, from Incompatible with the Conservation of Nature to Fully Protected (Table 1). In the CNMI, 57% of MPAs were classified as Fully Protected (n=4; 9.39 km^2). Two MPAs are species-specific protected areas, each overridden by local moratoria on the harvest of protected species. The sole Lightly Protected MPA in the CNMI is the Managaha Marine Conservation Area. In Guam, 75% of MPAs are either Highly or Fully Protected (n=6; 30.78 km^2), and two are Lightly Protected (8.06 km^2).

The MTMNM consists of three units, each with different management priorities. Two units (the Mariana Arc of Fire NWR and the Mariana Trench NWR) are managed as a part of the U.S. National Wildlife Refuge system and only prohibit extractive activities that impact the seafloor, rendering these areas Incompatible with the Conservation of Nature, per the MPA Guide. The Islands Unit, which covers 42,530.02 km^2 of ocean surrounding the three northernmost islands of the CNMI, is Highly Protected, allowing fishing for scientific exploration and research purposes and sustenance, recreational and traditional indigenous fishing.

4 Discussion

Modern spatially explicit marine conservation in the Mariana Islands is a complex lattice of local and federal laws, regulations, and jurisdictional authority. The 18 spatially managed areas within the Marianas, ranging from small to very large, encompass an area of 247,312.81 km^2 (25.47% of the combined EEZ). The majority of these areas are actively managed, the lone exception being the three units of the Mariana Trench Marine National Monument, where the management plan has been under development since 2009. Notably, the quantity and quality of marine conservation in the Mariana Islands are dependent on the jurisdictional scale of analysis (i.e., territorial waters vs. national EEZ): a mere 0.83% of Guam's territorial waters are in MPAs (0.79% in Fully/Highly Protected), but nearly a quarter of the EEZ is in an MPA, yet one that is Incompatible with the Conservation of Nature. MPAs in the Mariana Islands can be large, have strong protections, and dedicated management, but not three conditions simultaneously. These findings highlight the nuances of assessing area-based marine conservation, particularly when overlapping – and potentially contested – management authority is considered.

The MPA Guide states that, "fully or highly protected areas … having the greatest likelihood of achieving biodiverse and healthy

ecosystems, once the MPA is implemented or actively managed, if enabling CONDITIONS are in place" (Grorud-Colvert et al., 2021). Some of these conditions include adequate staffing, developing and implementing consistent monitoring, official management plans, and long-term financial commitments. MPAs lacking those features often fail to achieve their stated social and environmental goals (Gill et al., 2017). Our work provides one of the first regional applications of the MPA Guide, mainly focusing on the level of protection and stage of establishment. In the Mariana Islands, all MPAs within territorial waters, irrespective of administrating agency, are Actively Managed, but they vary in their level of protection. Given the number of MPAs and the total area protected identified as Actively Managed, this could indicate that social preconditions for attaining active management are present or that the number of MPAs does not exceed the managerial capacity of the region. For example, a large portion of marine conservation and fisheries management in the CNMI is supported by US federal grants, totaling approximately $6.1 million USD in 2019 (Table S2). This funding supports a range of activities, including MPA enforcement ($189,000 USD). As funding is often cited as a primary concern in conservation more broadly, the dollar-to-unit area support for locally administered MPAs in the CNMI is quite high (approximately $20,000 USD/km^2 of the 9.39 km^2 of Actively Managed areas). Ecosystem evaluations were conducted for the Mariana Islands (van Beukering et al., 2006; van Beukering et al., 2007), but a detailed audit of marine conservation funding, particularly targeted at MPAs, could provide managers with a financial roadmap to sustain present and future conservation.

Encouragingly, two-thirds of the MPAs in the territorial waters of the Mariana Islands are classified as either Highly or Fully Protected. The remaining areas were species-specific reserves currently overridden by local moratoria or Lightly Protected areas. All Lightly Protected areas had robust management of extractive activities but were some of the most popular recreational areas in the jurisdictions. The Mañagaha Marine Conservation Area on Saipan is a strict no-take area but is one of the most visited locations by tourists and residents alike (Schroer, 2005). Lightly Protected MPAs in Guam were also associated with high-use tourism areas (Tumon Bay and Piti Bomb Holes). Before the COVID-19 pandemic, total visitor arrivals to Guam were over 1.5 million people. The CNMI receives markedly fewer tourists but still exceeded 600,000 visitors in 2018. Given these numbers, the potential for high-impact, non-extractive tourism to undermine protection against extractive and depositional activities needs to be a focus for ongoing management (Thurstan et al., 2012). MPAs can be designed to align with the goals of other sectors, such as tourism (Viana et al., 2017). Identifying opportunities to upgrade Lightly Protected MPAs in the Mariana Islands could help achieve socioeconomic and environmental goals.

Two MPAs assessed in this study are species-specific management areas in the CNMI that are currently overridden by local moratoria on the protected species (the Laulau Bay Sea Cucumber Sanctuary and the Lighthouse Reef Trochus Sanctuary). From a management perspective, these MPAs are currently indistinguishable from non-MPA areas in the CNMI, in that the same rules, regulations, and activities are adhered to. Previous studies on species-specific MPAs, particularly small areas, suggest that these do little for overall biodiversity conservation (Novaczek et al., 2017). Given that these areas are already demarcated for protection, consideration should be given to upgrading the scope of protection here.

Our application of the MPA Guide coincided with an assessment of the 50 largest MPAs in the United States that also classified the Mariana Trench Marine National Monument (Sullivan-Stack et al., 2022). Our assessment diverged from Sullivan-Stack et al., who classified the area as Fully Protected, while we opted to classify this area as Incompatible with the Conservation of Nature. In its current iteration, the draft management plan for the Monument only prohibits extractive activities from the seafloor bed, leaving the water column open to extractive activities, albeit permitted (Marianas Trench Marine National Monument, 2020). A broad set of literature indicates seafloor ecosystems are linked with those in the water column (O'leary and Roberts, 2018), which has led the International Union for Conservation of Nature (IUCN) to oppose this type of vertical zonation (IUCN and WCPA, 2018). This discrepancy highlights the continuing challenges facing MPA assessments, despite numerous evaluation tools (Al-Abdulrazzak and Trombulak, 2012; Horta E Costa et al., 2016; Grorud-Colvert et al., 2021).

The present study is limited in several ways. First, our assessment of marine protection solely assesses the STAGE and LEVEL of protection. Investigating the full suite of social, ecological, and environmental/climate factors in each MPA can provide a more robust understanding of conservation's current and future status. Previous studies investigated some of the social dimensions of large MPAs (Richmond and Kotowicz, 2015), fisheries (Weijerman et al., 2016), and conservation-adjacent planning in the region (Grecni et al., 2021). MPA-specific work may reveal some of the social aspects associated with the patterns and trends shown in our work. For example, climate adaptation planning and policy in the neighboring Republic of the Marshall Islands is limited due to past and present geopolitical dynamics rooted in colonialism and empire (Bordner et al., 2020). Given the similar political histories between the islands, parallel processes emerging from colonialism may limit the number and types of MPAs in the Mariana Islands. In particular, colonialism, contested jurisdictional claims, and the resulting bureaucracy may be responsible for delaying the implementation of the MTMNM, despite its inception nearly two decades ago (Marianas Trench Marine National Monument, 2020).

Additionally, studies examining the climate outlook for coral reefs in the Mariana Islands indicate a wide range of resilience potentials (Maynard et al., 2015). Paired with approaches for projecting climate impacts and novelty in MPAs (Bruno et al., 2018; Johnson and Watson, 2021), climate-explicit assessments could be examined to help inform managers on what strategies to adopt. For example, differing post-coral bleaching event trajectories within marine reserves benefited different fish functional groups (Graham et al., 2020). While specific recovery trajectories are difficult to predict, managers may be able to integrate a suite of climate futures and the expected changes to biogeochemical conditions into their long-term planning (Fidler et al., 2021).

Lastly, MPAs are one of many tools available to resource managers and policymakers to safeguard and protect marine biodiversity. Complementary approaches, particularly other effective area-based conservation measures (OECMs), need to be assessed to give managers a more comprehensive view of marine conservation in the Mariana Islands. Recent work evaluating the impact of large MPAs on fishing pressure shows that many of these areas had little fishing (White et al., 2020), perhaps indicating a benefit of EEZ declaration. EEZs impose limitations on who can legally fish within the area, potentially acting as *de facto* MPAs if no domestic fishing is present (Relano et al., 2021). Fisheries in the tropical Pacific were significantly transformed by establishing EEZs in the region. A US-based industrial fishery sector in the Mariana Islands did not mature, removing all high-intensity, high-impact fishing (Barclay, 2014). An assessment of historical fisheries in the EEZ surrounding the Mariana Islands may indicate that the EEZ functions as an OECM.

5 Conclusion

Marine protected areas are a critical piece of the conservation puzzle. A history of colonialism and a lattice of jurisdictional authority in the Mariana Islands have produced a mosaic of marine conservation. Despite a mere fraction of nearshore and territorial waters being spatially managed, the protected areas are actively managed – one of the highest barriers to effective conservation and marine resource management. While an assessment of the social and ecological outcomes of marine protection is needed, in addition to a further examination of the role OECMs play in overall socio-environmental outcomes, the present study shows how an application of the MPA Guide can determine how future conservation interventions can be designed to benefit people in nature.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

Both authors designed the study. SMJ conducted analysis and wrote the first draft of the manuscript. Both authors made considerable contributions in revising successive versions of the manuscript and read and approved the submitted version.

Funding

This research was produced with support from the David and Lucile Packard Foundation [Grant ID: 2021-72277].

Acknowledgments

We want to acknowledge and thank the Friends of the Mariana Trench for their support in completing this work and their continued dedication to locally led science and conservation in the Mariana Islands. We also want to thank L. Swaddell for her review of an earlier version of this work.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2022.1012815/full#supplementary-material

References

Al-Abdulrazzak, D., and Trombulak, S. C. (2012). Classifying levels of protection in marine protected areas. *Mar. Policy* 36, 576–582. doi: 10.1016/j.marpol.2011.08.011

Albrecht, R., Cook, C. N., Andrews, O., Roberts, K. E., Taylor, M. F. J., Mascia, M. B., et al. (2021). Protected area downgrading, downsizing, and degazettement (PADDD) in marine protected areas. *Mar. Policy* 129, 104437. doi: 10.1353/aim.2020.0001

Asche, F., Garlock, T. M., Anderson, J. L., Bush, S. R., Smith, M. D., Anderson, C. M., et al (2018). Three pillars of sustainability in fisheries. *Proc Natl Acad Sci USA* 115, 11221–11225. doi: 10.1073/pnas.1807677115

Athens, J. S., Dega, M. F., and Ward, J. V. (2004). Astronesian colonization of the Mariana islands: The palaeoenvironmental evidence. *Bull. Indo-Pacific Prehistory Assoc.* 24, 21–30. doi: 10.7152/bippa.v24i0.11868

Barclay, K. (2014). "History of industrial tuna fishing in the pacific islands," in *Historical perspectives of fisheries exploitation in the indo-pacific*, (Switzerland: Springer Dordrecht) 153–171.

Beger, M., Mcgowan, J., Treml, E. A., Green, A. L., White, A. T., Wolff, N. H., et al. (2015). Integrating regional conservation priorities for multiple objectives into national policy. *Nat. Commun.* 6, 8208. doi: 10.1038/ncomms9208

Bennett, N. J., Katz, L., Yadao-Evans, W., Ahmadia, G. N., Atkinson, S., Ban, N. C., et al. (2021). Advancing social equity in and through marine conservation. *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.711538

Bordner, A. S., Ferguson, C. E., and Ortolano, L. (2020). Colonial dynamics limit climate adaptation in Oceania: Perspectives from the Marshall islands. *Global Environ. Change* 61, 102054. doi: 10.1016/j.gloenvcha.2020.102054

Bruno, J. F., Bates, A. E., Cacciapaglia, C., Pike, E. P., Amstrup, S. C., Van Hooidonk, R., et al. (2018). Climate change threatens the world's marine protected areas. *Nat. Climate Change* 8, 499–503. doi: 10.1038/s41558-018-0149-2

Carson, M. T. (2020). Peopling of Oceania: Clarifying an initial settlement horizon in the Mariana islands at 1500 BC. *Radiocarbon* 62, 1733–1754. doi: 10.1017/RDC.2020.89

Claudet, J., Bopp, L., Cheung, W. W. L., Devillers, R., Escobar-Briones, E., Haugan, P., et al. (2020). A roadmap for using the UN decade of ocean science for sustainable development in support of science, policy, and action. *One Earth* 2, 34–42. doi: 10.1016/j.oneear.2019.10.012

Coral Triangle Initiative (2009). *Regional plan of action, coral triangle initiative on coral reefs, fisheries and FoodSecurity (CTI-CFF).* (Manado, Indonesia: CTI-CFF Regional Secretariat).

Cuetos-Bueno, J. (2012). *Advancing the Micronesia challenge through community-based management of marine resources in piis-paneu, chuuk* (Saipan, MP: Pacific Marine Resources Institute).

Cuetos-Bueno, J., Hernandez-Ortiz, D., and Houk, P. (2018). Co-Evolution of "race-to-fish" dynamics and declining size structures in an expanding commercial coral-reef fishery. *Rev. Fish Biol. Fish.* 29, 147–160. doi: 10.1007/s11160-018-9542-1

Cuetos-Bueno, J., and Houk, P. (2014). Re-estimation and synthesis of coral-reef fishery landings in the commonwealth of the northern Mariana islands since the 1950s suggests the decline of a common resource. *Rev. Fish Biol. Fish.* 25, 179–194. doi: 10.1007/s11160-014-9358-6

Di Minin, E., and Toivonen, T. (2015). Global protected area expansion: Creating more than paper parks. *BioScience* 65, 637–638. doi: 10.1093/biosci/biv064

Fidler, R. Y., Andradi-Brown, D. A., Awaludinnoer,, Pada, D., Purwanto,, Hidayat, N. I., et al. (2021). The importance of biophysical context in understanding marine protected area outcomes for coral reef fish populations. *Coral Reefs* 40, 791–805. doi: 10.1007/s00338-021-02085-y

Flood, B. (2001). *Marianas Island legends: Myth and magic* (Hawaii: Bess Press).

Friedlander, A. M. (2018). Marine conservation in Oceania: Past, present, and future. *Mar. pollut. Bull.* 135, 139–149. doi: 10.1016/j.marpolbul.2018.05.064

Gaymer, C. F., Stadel, A. V., Ban, N. C., Cárcamo, P. F., Ierna, J., and Lieberknecht, L. M. (2014). Merging top-down and bottom-up approaches in marine protected areas planning: experiences from around the globe. *Aquat. Conserva.: Mar. Freshw. Ecosyst.* 24, 128–144. doi: 10.1002/aqc.2508

Gill, D. A., Mascia, M. B., Ahmadia, G. N., Glew, L., Lester, S. E., Barnes, M., et al. (2017). Capacity shortfalls hinder the performance of marine protected areas globally. *Nature* 543, 665–669. doi: 10.1038/nature21708

Graham, N., Robinson, J. P. W., Smith, S. E., Govinden, R., Gendron, G., and Wilson, S. K. (2020). Changing role of coral reef marine reserves in a warming climate. *Nat. Commun.* 11, 2000. doi: 10.1038/s41467-020-15863-z

Grecni, Z., Derrington, E. M., Greene, R., Miles, W., and Keener, V. (2021). "Climate change in the commonwealth of the northern Mariana islands: Indicators and considerations for key sectors," in *Report for the pacific islands regional climate assessment* (Honolulu, HI: East-West Center).

Grorud-Colvert, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta, E. C. B., Pike, E. P., et al. (2021). The MPA guide: A framework to achieve global goals for the ocean. *Science* 373, eabf0861. doi: 10.1126/science.abf0861

Gruby, R. L. (2017). Macropolitics of Micronesia: Toward a critical theory of regional environmental governance. *Global Environ. Polit.* 17, 9–27. doi: 10.1162/GLEP_a_00426

Guam Bureau of Statistics and Plans (2021) *Census of Guam*. Available at: https://bsp.guam.gov/census-of-guam/ (Accessed 7/4/2022).

Gubbay, S. (1995). "Marine protected areas - past, present, and future," in *Marine protected areas: principles and techniques for management*. Ed. S. Gubbay (London: Chapman & Hall), 1–14.

Horta E Costa, B., Claudet, J., Franco, G., Erzini, K., Caro, A., and Gonçalves, E. J. (2016). A regulation-based classification system for marine protected areas (MPAs). *Mar. Policy* 72, 192–198. doi: 10.1016/j.marpol.2016.06.021

Houk, P., Cuetos-Bueno, J., Tibbatts, B., and Gutierrez, J. (2018). Variable density dependence and the restructuring of coral-reef fisheries across 25 years of exploitation. *Sci. Rep.* 8, 5725. doi: 10.1038/s41598-018-23971-6

IUCN and WCPA (2018). *Applying IUCN's global conservation standards to marine protected areas (MPA): Delivering effective conservation action through MPAs, to secure ocean health and sustainable development* (Gland, Switzerland: IUCN).

Johannes, R. E. (1978). Traditional marine conservation methods in Oceania and their demise. *Annu. Rev. Ecol. Syst.* 9, 349–364. doi: 10.1146/annurev.es.09.110178.002025

Johnson, S. M., and Watson, J. R. (2021). Novel environmental conditions due to climate change in the world's largest marine protected areas. *One Earth* 4, 1625–1634. doi: 10.1016/j.oneear.2021.10.016

Kark, S., Levin, N., Grantham, H. S., and Possingham, H. P. (2009). Between-country collaboration and consideration of costs increase conservation planning efficiency in the Mediterranean basin. *Proc. Natl. Acad. Sci. U.S.A.* 106, 15368–15373. doi: 10.1073/pnas.0901001106

Mañagaha Marine Conservation Act (2000). *12th CNMI legislature, 2nd special session* (Saipan, MP: CNMI Law Revision Commission).

Marcos, C., Díaz, D., Fietz, K., Forcada, A., Ford, A., García-Charton, J. A., et al. (2021). Reviewing the ecosystem services, societal goods, and benefits of marine protected areas. *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.613819

Marianas Trench Marine National Monument (2020). *Draft Marianas trench marine national monument management plan and environmental assessment.* (Honolulu, HI: NOAA Pacific Islands Regional Office).

Maynard, J. A., Mckagan, S., Raymundo, L. J., Johnson, S. M., Ahmadia, G. N., Johnston, L., et al. (2015). Assessing relative resilience potential of coral reefs to inform management. *Biol. Conserv.* 192, 109–119. doi: 10.1016/j.biocon.2015.09.001

Montambault, J. R., Wongbusarakum, S., Leberer, T., Joseph, E., Andrew, W., Castro, F., et al. (2015). Use of monitoring data to support conservation management and policy decisions in Micronesia. *Conserv. Biol.* 29, 1279–1289. doi: 10.1111/cobi.12542

NOAA Fisheries (2013). *Compliance guide: Requirements for fishing in the Marianas trench, pacific remote islands, and rose atoll marine national monuments.* Ed. D. O. Commerce (Honolulu, HI:NOAA Pacific Islands Regional Office).

Novaczek, E., Howse, V., Pretty, C., Devillers, R., Edinger, E., and Copeland, A. (2017). Limited contribution of small marine protected areas to regional biodiversity: The example of a small Canadian no-take MPA. *Front. Mar. Sci.* 4, 174. doi: 10.3389/fmars.2017.00174

O'leary, B. C., and Roberts, C. M. (2018). Ecological connectivity across ocean depths: Implications for protected area design. *Global Ecol. Conserv.* 15, e00431. doi: 10.1016/j.gecco.2018.e00431

Public Law 11-63 (1999). *111th CNMI Legislature, First Regular Session* (Saipan, MP: CNMI Law Revision Commission).

Public Law 12-46 (2001). *12th CNMI legislature, 2nd special session* (Saipan, MP: CNMI Law Revision Commission).

Public Law 15-90 (2007). *15th CNMI legislature, 2nd special session* (Saipan, MP: CNMI Law Revision Commission).

Public Law 17-14 (2010). *17th CNMI legislature, 6th special session* (Saipan, MP: CNMI Law Revision Commission).

Public Law 24-14 (1997). *24th Guam legislature, 1st regular session* (Saipan, MP: Guam Law Revision Commission).

Public Law 94-241 (1976). *94th U.S. congress* (Saipan, MP: Office of the Law Revision Counsel of the United States House of Representatives).

Reimer, J. M., Devillers, R., and Claudet, J. (2020). Benefits and gaps in area-based management tools for the ocean Sustainable Development Goal. *Nature Sustainability* 4, 349–357. doi: 10.1038/s41893-020-00659-2

Relano, V., Palomares, M. L. D., and Pauly, D. (2021). Comparing the performance of four very Large marine protected areas with different levels of protection. *Sustainability* 13, 9572. doi: 10.3390/su13179572

Richmond, L., and Kotowicz, D. (2015). Equity and access in marine protected areas: The history and future of 'traditional indigenous fishing' in the Marianas trench marine national monument. *Appl. Geogr.* 59, 117–124. doi: 10.1016/j.apgeog.2014.11.007

Roberson, L. A., Beyer, H. L., O'hara, C., Watson, J. E. M., Dunn, D. C., Halpern, B. S., et al. (2021). Multinational coordination required for conservation of over 90% of marine species. *Glob. Chang. Biol.* 27, 6206–6216. doi: 10.1111/gcb.15844

Roberts, C. M., O'leary, B. C., Mccauley, D. J., Cury, P. M., Duarte, C. M., Lubchenco, J., et al (2017). Marine reserves can mitigate and promote adaptation to climate change. *Proc Natl Acad Sci USA* 114, 6167–75. doi: 10.1073/pnas.1701262114

Rota Local Law 9-2 (1994). *9th CNMI legislature* (CNMI Law Revision Commission).

Schroer, G. (2005). *Management plan for the managaha marine conservation area* (Saipan, MP: DLNR. Division of Fish & Wildlife).

Singleton, R. L., and Roberts, C. M.. (2014). The contribution of very large marine protected areas to marine conservation: giant leaps or smoke and mirrors? *Mar. Pollut. Bull.* 87, 7–10. doi: 10.1016/j.marpolbul.2014.07.067

Sullivan-Stack, J., Aburto-Oropeza, O., Brooks, C. M., Cabral, R. B., Caselle, J. E., Chan, F., et al. (2022). A scientific synthesis of marine protected areas in the united states: Status and recommendations. *Front. Mar. Sci.* 9. doi: 10.3389/fmars.2022.849927

SWCA Environmental Consultants (2010a). *Haputo ecological reserve area general management plan, naval base Guam*. (Saipan, MP: CNMI Division of Fish and Wildlife).

SWCA Environmental Consultants (2010b). *Orote peninsula ecological reserve area general management plan, naval base Guam*. (Saipan, MP: CNMI Division of Fish and Wildlife).

The Micronesia Challenge (2006). *Declaration of commitment: The Micronesia challenge*.

Thurstan, R. H., Hawkins, J. P., Neves, L., and Roberts, C. M. (2012). Are marine reserves and non-consumptive activities compatible? a global analysis of marine reserve regulations. *Mar. Policy* 36, 1096–1104. doi: 10.1016/j.marpol.2012.03.006

UNEP-WCMC and IUCN (2022) *Protected planet: the world database on protected areas (WDPA)* (Cambridge, UK: UNEP-WCMC and IUCN). Available at: www.protectedplanet.net (Accessed January 2022).

US Census Bureau (2021) *2020 island areas censuses: Commonwealth of the northern Mariana islands (CNMI)*. Available at: https://www.census.gov/data/tables/2020/dec/2020-commonwealth-northern-mariana-islands.html (Accessed 7/4/2022).

van Beukering, P., Haider, W., Longland, M., Cesar, H. S. J., Sablan, J., Shjegstad, S., et al. (2007). *The economic value of guam's coral reefs*. (Mangilao, GU: University of Guam Marine Laboratory).

van Beukering, P., Haider, W., Wolfs, E., Liu, Y., van der Leeuw, K., Longland, M., et al. (2006). *The economic value of the coral reefs of saipan, commonwealth of the northern Mariana islands*. (Silver Spring, MD: NOAA Coral Reef Conservation Program).

Viana, D. F., Halpern, B. S., and Gaines, S. D. (2017). Accounting for tourism benefits in marine reserve design. *PloS One* 12, e0190187. doi: 10.1371/journal.pone.0190187

Weijerman, M., Grace-Mccaskey, C., Grafeld, S. L., Kotowicz, D. M., Oleson, K. L. L., and Van Putten, I. E. (2016). Towards an ecosystem-based approach of guam's coral reefs: The human dimension. *Mar. Policy* 63, 8–17. doi: 10.1016/j.marpol.2015.09.028

White, T. D., Ong, T., Ferretti, F., Block, B. A., Mccauley, D. J., Micheli, F., et al. (2020). Tracking the response of industrial fishing fleets to large marine protected areas in the pacific ocean. *Conserv. Biol.* 34, 1571–1578. doi: 10.1111/cobi.13584

WPRFMC (2021). *Annual stock assessment and fishery evaluation report for the Mariana archipelago fishery ecosystem plan 2020*. Eds. T. Remington, M. Sabater and A. Ishizaki (Honolulu, HI: Western Pacific Regional Fishery Management Council).

Zupan, M., Fragkopoulou, E., Claudet, J., Erzini, K., Horta E Costa, B., and Gonçalves, E. J. (2018). Marine partially protected areas: drivers of ecological effectiveness. *Front. Ecol. Environ.* 16, 381–387. doi: 10.1002/fee.1934