Title: Protected area downgrading, downsizing, and degazettement (PADDD) in marine protected areas

Authors: Renee Albrecht[1,2], Carly N. Cook[3], Olive Andrews[4,5], Kelsey E. Roberts[6,3], Martin F. J. Taylor[7], Michael B. Mascia[1], Rachel E. Golden Kroner[1]

Affiliations:
1 –Moore Center for Science, Conservation International, 2011 Crystal Drive, Suite 600, Arlington, VA 22202, USA

2 –Bren School of Environmental Science & Management, University of California - Santa Barbara, 2400 Bren Hall, Santa Barbara, CA 93106, USA

3 –School of Biological Sciences, Monash University, Clayton, VIC, 3800 Australia

4 –Whaleology, 37 Hekerua Road, Oneroa, Auckland, New Zealand

5 –Conservation International, University of Auckland Building 302, Room 331, 23 Symonds Street, Auckland 1010, New Zealand

6 –School of Marine and Atmospheric Sciences, Stony Brook University, 145 Endeavor Hall Stony Brook, NY 11794, USA

7 –World Wildlife Fund-Australia, 4/340 Adelaide Street, Brisbane QLD 4179, Australia

Highlights

- Protected area downgrading, downsizing, and degazettement (PADDD) affects MPAs
- We documented patterns, trends, and causes of enacted and proposed PADDD in MPAs
- Widespread downgrading in Australia authorized commercial and recreation fishing
- Downgrades to the Coral Sea Marine Park constitute the largest PA downgrade to date
- Science and policy responses are required to safeguard MPAs in the long term

Abstract

Marine protected areas (MPAs) are foundational to global marine biodiversity conservation efforts. Recently, countries have rapidly scaled up their MPA networks to meet targets established by the Convention on Biological Diversity (CBD). While MPA networks are intended to permanently safeguard marine ecosystems, evidence points to widespread legal changes that temper, reduce, or eliminate protected areas, known as protected area downgrading, downsizing, and degazettement (PADDD). Research on PADDD to-date has focused on terrestrial PAs, leaving fundamental questions about PADDD in MPAs unanswered. To address this knowledge gap and provide a foundation for understanding the conservation implications of PADDD in marine ecosystems, we documented patterns, trends, and proximate causes of PADDD in MPAs globally. At least six countries have enacted 44 PADDD events in MPAs, most of which were in Australian MPAs. Globally, PADDD events in MPAs have affected an area of at least 1,198,774 square kilometers, approximately the size of South Africa. Most PADDD events in MPAs (67%) are associated with industrial-scale resource use, extraction, and development, suggesting that PADDD may undermine the conservation objectives of MPAs. Additional research, transparency, and proactive policy responses are needed to address PADDD to better safeguard marine ecosystems.

Keywords: protected areas; protected area downgrading, downsizing, and degazettement; PADDD; marine protected areas; commercial fishing; Australia

1. Introduction

Healthy oceans are essential to life on Earth. Home to critical biodiversity, oceans support fishing and tourism industries and provide essential ecosystem services, such as carbon storage and nutrient cycling [1]. Marine ecosystems are increasingly under threat from anthropogenic stressors, including overfishing, shipping, pollution, and climate change [2,3]. Collectively, these stressors degrade marine ecosystems, posing a significant threat to marine biodiversity and the essential ecosystem services provided by oceans [4,5].

Marine protected areas (MPAs) are fundamental to conservation efforts globally and are increasingly implemented to reduce anthropogenic stressors affecting marine ecosystems [6,7]. Parties to the Convention on Biological Diversity (CBD) committed to increase the extent of global protected areas (PAs) to 10% of oceans by 2020 [8] and this target is also included in Sustainable Development Goal 14 [9]. Recently, International Union for the Conservation of Nature (IUCN) members called for protection of 30% of the ocean by 2030 [10,11], which is reflected in the zero draft of the 2030 CBD post-2020 strategic plan. Within the last decade, nations have expanded MPAs at an unprecedented rate [12], which is likely to continue to meet future targets.

While a rapidly expanding network of MPAs is intended to safeguard biodiversity in perpetuity, increasing evidence points to widespread legal changes that temper restrictions, shrink boundaries, and eliminate PAs [13]. These changes are known as protected area downgrading, downsizing, and degazettement (PADDD) events [14]. Most PADDD events are associated with expanded industrial-scale resource extraction and development, suggesting that PADDD may undermine PA conservation objectives [13]. Research on PADDD to-date has focused on terrestrial PAs, leaving fundamental questions about PADDD in MPAs unaddressed. To fill this knowledge gap, we documented and analyzed patterns, trends, and proximate causes of PADDD in MPAs globally, with emphasis on Australia - a hotspot of PADDD events [15]. Results provide insights regarding the conservation implications of PADDD in marine ecosystems and support the importance of proactive policy responses to more effectively safeguard MPAs in the long term.

2. Methods

2.1 *Study Site and Scope*

MPAs in the global ocean span over 27,000,000 km^2 [12], an area approximately three times the size of China. The global ocean can be separated into waters under national jurisdiction, those within the Exclusive Economic Zones (EEZ) of coastal states, and international waters, which are outside national jurisdictions. Collectively, MPAs cover 7.6% of the global ocean and 17.5% of waters under national jurisdiction [12].

To conduct a preliminary investigation of PADDD in MPAs, we documented marine PADDD events systematically in Australia by reviewing all relevant legal documents (enacted or proposed between 2007 to 2019); we identified PADDD opportunistically in other countries [13,16] (See Supplementary Text, Methods and Results). Systematic data collection focused in Australia due to the high incidence of recent Australian marine PADDD events [17], including a large downgrade event in 2018 that affected several MPAs simultaneously (hereafter referred to as the 2018 Australian Systemic Downgrade) (Table 1). Australia has rapidly expanded its MPA coverage and is widely viewed as a global leader in MPA implementation [18]. At 3.3 million km^2, Australia's MPA system is among the largest in the world, covering approximately a third of the country's EEZ [19]. Australian MPAs can be established under Commonwealth (national), state, or territory jurisdictions. State and territory jurisdiction extend up to three nautical miles from Australia's coastal baseline. Commonwealth Government jurisdiction extends from 3 to 200 nautical miles with MPAs spanning five planning regions (North, North-west, South-west, South-east, Temperate East) and the Coral Sea Marine Park (Figure S1).

Table 1. Chronology of key events in the history of Australian Marine Parks (Commonwealth MPAs proclaimed under the *Environment Protection and Biodiversity Conservation Act* in 2007 and 2013).

Date	Event
2007	South-east Commonwealth Marine Reserve Network established under *Environment Protection and Biodiversity Conservation Act 1999.*
2012	Commonwealth marine reserves established under *Environment Protection and Biodiversity Conservation Act 1999* over 5 regions (Coral Sea, North, North-west, South-west and Temperate East).
2013	Management plans approved for Coral Sea, North, North-west, South-west and Temperate East regions to come into effect in 2014.
2013	Federal government changed following the 2013 election. The new government re-proclaimed marine reserves established in 2012 and declared intentions to revisit zoning and marine reserve management plans.
2014	Independent review commissioned of MPA zoning in the Coral Sea, North, North-west, South-west and Temperate East regions.
2016	Review panel released proposed zoning which would have reduced no-take Marine National Park Zones in the Coral Sea but increased Marine National Park Zones within other regions.
2017	The government changed the name of Commonwealth MPAs from “Marine Reserves” to “Marine Parks” via amending proclamation. The Director of National Parks proposed management plans that revoked and replaced previous plans. The proposed plans significantly alter zoning of MPAs relative to the original zoning and review panel recommendations.
2018	New management plans enacted following a series of failed disallowance motions attempted in the Senate.

2.2 *Identifying Marine PADDD and Collecting Data*

In this study, we included MPAs that fall exclusively in the ocean, as well as PAs spanning the intertidal zone when the PADDD event was enacted or proposed in the marine portion of the PA. This analysis combined published data on PADDD (including PADDD events in MPAs from [13,17]), with previously unpublished data. To identify marine PADDD events from previously published data, spatial data from [13] was clipped to the World Vector Shoreline to exclude PADDD events that overlapped exclusively with land. To verify that the remaining PADDD events occurred either entirely in the ocean or affected the marine components of PAs spanning the intertidal zone, we examined the proximate causes and supporting details of the PADDD events. PADDD events with the proximate cause of “fisheries” (e.g. industrial-scale fishing operations) were included (n=16). For proximate causes that could be terrestrial or marine (e.g. mining), the supporting details for the PADDD event were manually checked to determine whether the PADDD event affected only the terrestrial portion of a coastal PA. PADDD events with unknown proximate causes or land-based proximate causes, such as rural settlements and land-based infrastructure (e.g. buildings, roads), were excluded. Only PADDD events in which proximate causes were associated with marine zones were included (n=28). In addition to “fisheries,” proximate causes included recreational fishing, tourism (recreational diving), industrialization (shipbuilding yards), and infrastructure (marina development).

To collect new data for PADDD events in MPAs, we followed methodology established by [20] (updated by [21]) and used in [13,15]; and others. We identified potential PADDD events opportunistically by searching news reports and published literature for “protected area,” “marine reserve,” and “marine park”.

Once a potential PADDD event was identified, established definitions, methods, and decision trees were used to determine if a legal change constituted a PADDD event. Each confirmed PADDD event was then classified as downgrade, downsize, or degazettement accordingly [21]. Once a PADDD event was confirmed, information was collected for 48 attributes describing the location, timing, size, proximate cause(s), and other descriptive information [21]. Attributes were populated using details from primary and secondary documents, including government reports, peer-reviewed publications, and gray literature that was identified through iterative searches after each event was confirmed. Next, publicly available spatial data were used to map the boundaries of PADDD events. When public spatial data were unavailable, maps were digitized from legal documents. Finally, data were analyzed and results summarized to report extent, spatial and temporal patterns, and proximate causes.

2.3 *Identifying and Collecting Data on Australian Marine PADDD*

Given the high density and heterogeneity of PADDD events in Australia, especially the incidence of the 2018 Australian Systemic Downgrade, we examined PADDD events in Australia in detail at the level of each zone within each MPA. Within the context of Australian MPAs, zones distinguish which commercial and recreational activities are authorized within certain areas of an MPA. Jurisdictions specify permitted activities within relevant legislation for each zone and assign IUCN categories to zones which may differ from the IUCN category of the overall MPA. Zone names are associated with various levels of protection and IUCN categories ranging from no-take (e.g. Sanctuary Zones and National Park Zones) to extractive uses (e.g. Special Purpose Zones and Multiple Use Zones). The activities permitted in each zone vary among jurisdictions [22] and between management plans for different MPAs under the same jurisdiction.

To document the 2018 Systemic Downgrade event, we compared management plans from 2014 and 2018 to each other for the Coral Sea Marine Park and the following planning regions: North-west, South-west, North, and Temperate East [23–32]. Portions within MPAs where the zone boundary or zone name changed between 2014 and 2018, as indicated by differences in the two management plans, were noted as potential PADDD events. Changes to restrictions on activities between 2014 and 2018 were only considered as part of this analysis if they were explicitly referenced in both the 2014 and 2018 management plans. Decision trees from [21] and the comparisons of "Summary of rules for activities" tables in the management plans were used to determine if observed zoning changes constituted PADDD events. In Australia, approved management plans constitute legislative instruments; therefore, changes authorizing new anthropogenic activities constitute PADDD events under established methods [21]. For confirmed PADDD events, each zoning change within MPAs was classified as either a downgrade or an offset (regulatory changes that increased restrictions simultaneously and/or as compensation for PADDD) based on definitions from [21]. PADDD events were recorded at the level of each PA, rather than at the level of each zoning change, for consistency with the global database. Australian MPAs that were upgraded but were not affected by a PADDD event were excluded from this analysis (See Supplementary Text, Methods and Results Table 1).

Management plans and other primary and secondary documents were used to collect information on the location, timing, size, proximate cause(s), and other descriptive information for Australian PADDD events [21]. For discrepancies in attribute information between sources, management plans were used as the primary source. To map PADDD events in Australia, publicly available data from the Collaborative Australian Protected Areas Database (CAPAD) and the Australian Government Department of the Environment and Energy were used [33,34]. These data were compared to management plan zoning maps to ensure consistency. While there were some inconsistencies in the descriptive attributes of the CAPAD data when compared to information in management plans, the MPA and zone boundaries of the CAPAD spatial data matched the management plans. These boundaries were used to create polygons in the location of identified downgrades and offsets and calculate the associated area affected values. Spatial data were analyzed in ArcGIS (version 10.7.1), using the cylindrical equal area projection for calculating area and the WGS 84 coordinate system for mapping.

3. Results

3.1 *Global Extent and Patterns*

Globally, governments of at least six countries enacted 44 PADDD events in 37 MPAs (Australia, Croatia, Dominican Republic, Palau, South Africa, and the United States) affecting an area of at least 1,198,773.74 km^2, or approximately 4% of the total global MPA estate (Figure 1). Downgrading was most common (n=41), followed by downsizing (n=2), and degazettement (n=1). Enacted PADDD events removed protections from at least 94,981.50 km^2 of MPAs and tempered restrictions in an additional 1,103,792.24 km^2. In addition, two countries (Brazil and Jamaica) proposed four PADDD events in three MPAs. Proposed downgrading (n=2) and proposed downsizing (n=2) were equally common; we did not identify proposed degazettements. In the instance of three of the four proposed marine PADDD events, MPAs maintained protections because the proposed legal changes were either voted against or withdrawn. One proposed marine PADDD event in Brazil is pending, as of August 2020. See Table S1 for list of events and supporting details.

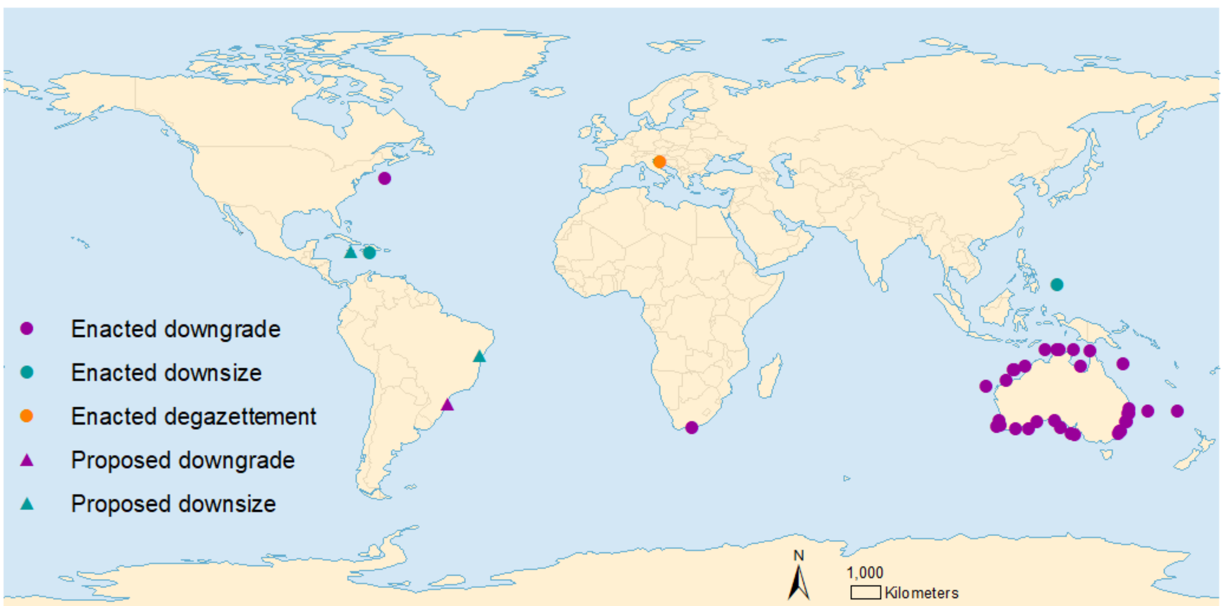

Figure 1. Spatial distribution of enacted and proposed PADDD events in marine protected areas globally, by August 2020.

3.2 *Global Temporal Trends*

Instances of marine PADDD events date back to 2001 when a downgrade to Arvoredo Marine Biological Reserve in Brazil was proposed to allow access for tourism (recreational diving). Of the 40 MPAs in which PADDD events were enacted or proposed, approximately 15% (n=6) were affected more than once. The first identified case of an enacted PADDD event in MPAs dates back to 2004. Since then, enacted marine PADDD events have increased steadily until a rapid increase in 2018, mostly associated with the 2018 Australian Systemic Downgrade (Figure 2). The length of time between MPA gazettement and enacted PADDD events ranged from 3 to 29 years (mean = 8.84, sd = 5.36) (Figure S2).

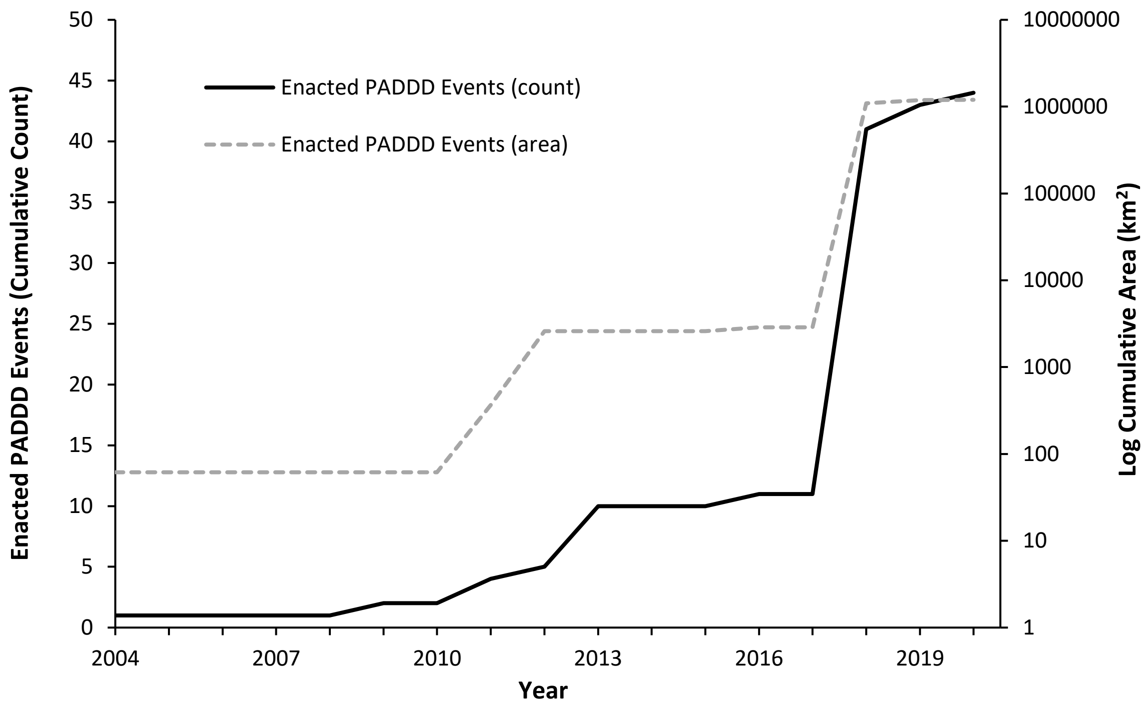

Figure 2. Temporal trends of enacted PADDD events in marine protected areas globally. The 2018 Australian Systemic Downgrade contributed to a substantial increase in the global count and area affected by marine PADDD events.

3.3 *Global Proximate Causes*

Globally, proximate causes of enacted marine PADDD events were diverse but primarily centered around access to and use of biological resources (commercial and recreational fishing activities). Many PADDD events (n=22) were associated with multiple proximate causes wherein a single legal change newly authorized several different activities (Figure S3). The majority (67%) of all enacted marine PADDD events with known proximate causes (n=43) were associated with industrial-scale resource use, extraction, and development, either as the only proximate cause or as one of multiple causes (n=29) (Figure 3). Specific proximate causes classified as industrial-scale use, extraction, and development included: newly authorized commercial fishing activities, anchoring (for commercial ships), commercial aquaculture and pearling, mining and associated operations, dredging and disposal of dredged material, infrastructure (marina development), industrialization (tourism development), and ballast water discharge. Within the categorization of industrial-scale use, extraction, and development, most enacted marine PADDD events (60%) were associated with commercial fishing activities, either as the only proximate cause or as one of multiple proximate causes (n=26).

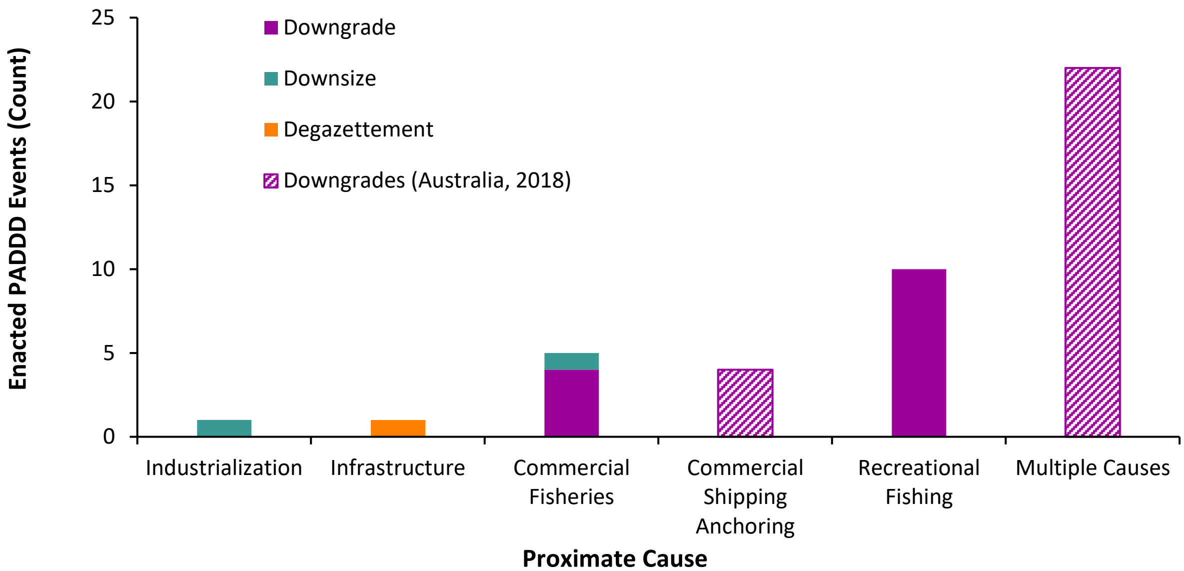

Figure 3. Proximate causes of enacted marine PADDD events globally (and the 2018 Australian Systemic Downgrade, striped bars) with known proximate causes (n=43). Most PADDD events (n=29) were associated with industrial-scale resource use, extraction, and development either as the only proximate cause or as one of multiple proximate causes. The proximate cause for one event was unknown. Further details in Section 3.6 *Australia Proximate Causes.*

3.4 *Australia Extent and Patterns*

The 2018 Australian Systemic Downgrade tempered restrictions in at least 26 MPAs (which we categorize as 26 PADDD events) under the Commonwealth Government's jurisdiction in the Coral Sea Marine Park as well as the North, North-west, South-west, South-east, and Temperate East planning regions. Collectively, these 26 PADDD events represent 71 zone changes that authorized one or more new activities within the affected MPAs. These 26 PADDD events tempered restrictions in at least 1,088,277.64 km^2, or approximately 33% of the total Australian MPA estate, which has a total extent of 3.3 million km^2 (Figure 4) [19]. Downgrades within 20 MPAs were fully or partially offset by increases to restrictions (regulatory offsets) on one or more activities within the same zone or elsewhere within the same MPA. This resulted in increased protection in at least 509,978.31 km^2, or 15%, of the total Australian MPA estate. The area affected by downgrades ranged from 58.24 km^2 in Perth Canyon Marine Park to 740,275.06 km^2 in the Coral Sea Marine Park (median = 1,586.79 km^2). The downgrade to the Coral Sea Marine Park affected 75% of the total area of the MPA and constitutes the largest downgrade to a single (marine or terrestrial) protected area in history worldwide.

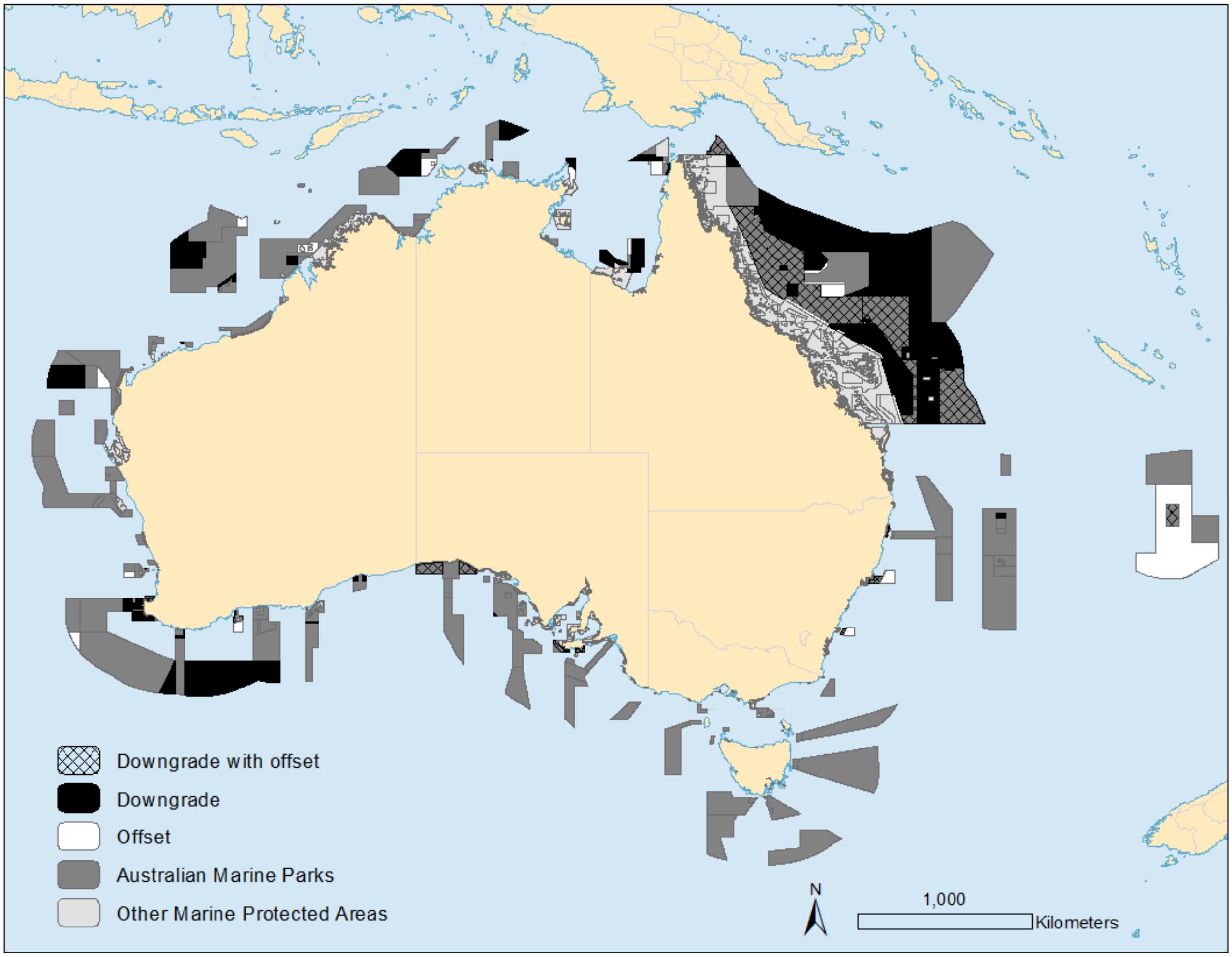

Figure 4. Spatial patterns of PADDD events associated with the 2018 Australian Systemic Downgrade. The black, white, and hatched shapes represent zones within MPAs where the Australian government newly authorized one or more anthropogenic activities (black; downgrade), newly restricted one or more anthropogenic activities (offset; white) or both newly restricted and newly authorized simultaneously (downgrade with offset; hatch pattern) between 2014 and 2018. Light gray areas represent state and territory MPAs and the Great Barrier Reef Marine Park.

An additional 13 PADDD events were enacted in six Australian MPAs under state or territorial jurisdiction. Collectively, these 13 downgrades tempered restrictions in at least 2,537 km^2, however, the exact area for many of these PADDD events is unknown. As of December 2019, there were no identified proposed marine PADDD events in Australian MPAs under Commonwealth, state, or territory jurisdiction.

3.5 *Australia Temporal Trends*
The first PADDD events in the Australian MPA network were enacted in 2011 following a formal rezoning implemented after a change in government under New South Wales jurisdiction [17]. Most enacted PADDD events in Australian MPAs were systemic (n=37), whereby one legal action affected multiple MPAs simultaneously. All of the 26 MPAs under Commonwealth jurisdiction that were downgraded in the 2018 Australian Systemic Downgrade were gazetted in 2012 and none had been previously affected by PADDD events.

3.6 *Australia Proximate Causes*
Of the 26 PADDD events associated with the 2018 Australian Systemic Downgrade, 85% (n = 22) were

associated with multiple proximate causes as a result of zoning changes that tempered restrictions on several activities simultaneously within portions of the MPA (Figure 4). The most extensive zone change by area (317,591.77 km^2) and number of MPAs affected (n=9) was a downgrade from no-take Marine National Park Zones (Category II) to Habitat Protection Zones (Category IV), which allow most forms of commercial fishing (Figure S4). The most frequent proximate causes (either as the only proximate cause or one of multiple proximate causes) included anchoring (for commercial ships) (n=21, affecting 374,846.01 km^2) and commercial fishing activities (n=21, affecting 930,096.87 km^2) (Table 2). Within the 21 MPAs in which restrictions on commercial fishing activities were tempered, the most frequently affected fishing activities were: pelagic longline (n=15), purse seine (n=15), minor line (n=15), dropline (n=15), hand collection (n=15), and demersal and/or midwater trawling (n=14) (further details in Tables S2A-S3D).

The additional 13 PADDD events that affected MPAs under state or territory jurisdiction were primarily associated with the government of New South Wales' rezoning of MPAs to allow recreational fishing in 2013, 2018, and 2019 (n=10). Following a review by an independent Marine Estate Expert Knowledge Panel, five of the ten New South Wales PADDD events associated with recreational fishing were fully or partially reversed in 2014 [35].

Table 2. Proximate causes of enacted PADDD events associated with the 2018 Australian Systemic Downgrade.

	Commercial Shipping Anchoring	Commercial Fishing Activities	Commercial Pearling	Commercial Aquaculture	Charter Fishing Tours	Recreational Fishing	Mining	Dredging and Disposal of Dredged Material	Ballast Water Discharge and Exchange
Arafura Marine Park	X	X							
Argo-Rowley Terrace Marine Park	X	X	X	X	X	X	X[1]	X	
Bremer Marine Park	X	X		X	X	X		X	
Coral Sea Marine Park	X	X			X	X			
Dampier Marine Park		X	X	X	X	X			
Eastern Recherche Marine Park	X	X		X	X	X	X[1]	X	
Gascoyne Marine Park		X	X	X	X	X			
Geographe Marine Park	X	X		X	X	X		X	
Great Australian Bight Marine Park	X								
Gulf of Carpentaria Marine Park	X	X			X	X	X[1]	X	
Hunter Marine Park	X	X							
Jervis Marine Park	X	X							
Kimberley Marine Park		X	X	X	X	X			
Lord Howe Marine Park	X	X			X	X	X[1]		
Mermaid Reef Marine Park							X[2]		X
Norfolk Marine Park	X								
Oceanic Shoals Marine Park	X	X							
Perth Canyon Marine Park		X		X	X	X			
Solitary Islands Marine Park	X	X							
South-west Corner Marine Park	X	X		X	X	X	X[1]	X	
Southern Kangaroo Island Marine Park	X								
Twilight Marine Park	X	X		X	X	X		X	
Wessel Marine Park	X	X			X	X	X[1]	X	
West Cape York Marine Park	X	X			X	X			
Western Eyre Marine Park	X	X							
Western Kangaroo Island Marine Park	X								
Total number of MPAs affected	**21**	**21**	**4**	**10**	**15**	**15**	**7**	**8**	**1**

[1] mining operations including exploration
[2] construction and operation of pipelines

4. Discussion

4.1 *Implications for Science*

This preliminary study demonstrates that marine PADDD is more widespread than previously known, adding to evidence of extensive PADDD in terrestrial PAs [13,15]. The results of this study suggest some similarities between terrestrial and marine PADDD. For instance, downgrading is the most common type of PADDD event in both marine and terrestrial PAs. Notably, downgrades in MPAs typically affect a significantly larger area than terrestrial downgrades, as related to the larger spatial extent of MPAs relative to terrestrial PAs [12]. In both terrestrial and marine PAs, most PADDD events were associated with industrial-scale resource extraction and development; for terrestrial PAs, this includes forestry and industrial agriculture [13] and can accelerate forest loss [36]. For MPAs, most PADDD events (60%) were associated with commercial fishing, which contradict MPA objectives to limit biodiversity exploitation [37,38].

Among the greatest threats to marine biodiversity that MPAs have the capacity to mitigate are the direct and indirect impacts of fishing [39]. On one hand, removing protections to authorize commercial fishing may have significant implications for MPA performance for biodiversity conservation. However, impacts of PADDD may be less severe if legal changes shift PAs from no-take to sustainable use through authorization of new local harvest or tourism; both no-take and sustainable use marine reserves can provide conservation benefits when well-managed [40,41]. Future research is needed to determine the social and ecological impacts of different types of PADDD events in each context. Overall, as most PADDD events in MPAs were related to industrial-scale resource use, extraction, and development, this evidence suggests that PADDD may compromise the conservation objectives of MPAs.

The potentially widespread nature of marine PADDD challenges assumptions of MPA permanence that often underlie MPA planning, design, and evaluation [14,17]. For instance, considering PADDD history in the design of MPAs [42] may help networks remain robust and effective over the long term. Findings also underscore the importance of considering PADDD in evaluations of MPA impact to reduce survivorship bias [43]. PADDD may also have implications for climate mitigation potential of PAs, as strictly protected PAs in certain countries are more effective at avoiding blue carbon emissions from mangrove loss relative to PAs that allow some resource extraction [44].

While this initial study offers novel insights, fundamental knowledge gaps about marine PADDD remain. Systematic archival research is needed to provide a more complete picture of patterns, trends, and causes of marine PADDD globally, beyond Australia. Further research is also needed to determine the ecological and social impacts of marine PADDD events, which are currently unknown; real-time automated identification system (AIS) vessel tracking data could support this effort [45]. The conservative results of this study demonstrate that PADDD events occur in areas of global importance for biodiversity [46], emphasizing the importance of understanding the consequences of PADDD, especially for events that authorize new or expanded commercial fishing or industrial activity. This study also raises questions related to governance, management, and political economy. For instance, do negotiations surrounding PADDD catalyze anticipatory fishing effort, similar to the increases in fishing seen in areas earmarked for future MPAs [47]? Is PADDD in MPAs related to lack of enforcement, as has been observed in terrestrial PAs [43]? Future research should also explore the biophysical and sociopolitical risk factors associated with higher probabilities of PADDD in MPAs, complementing studies in terrestrial PAs [42,43,48].

4.2 *Implications for Policy*

While more research on marine PADDD is needed, existing evidence provides a sufficient foundation to inform initial policy responses to marine PADDD. First, standardized tracking and public reporting of

PADDD as a key performance indicator for PAs is critical [13]; increased transparency would facilitate scientific research and performance measurement [49]. Such a process could be facilitated through the CBD's Post-2020 Framework [50,51], with data integrated into the World Database of Protected Areas. Future mobile MPAs with shifting boundaries implemented as a climate change adaptation strategy [52] represent an emerging transparency challenge, further underscoring the importance of standardized monitoring and public reporting of PADDD.

As countries move toward increased coverage of MPAs globally, there is a need for greater transparency about which activities are authorized within MPAs. Recent calls [53] and IUCN MPA standards [54] (which could support CBD signatory nations in reporting against CBD targets), emphasize that MPAs should be free of industrial-scale extractive activities. Many MPAs, including sites downgraded to authorize industrial-scale activities (e.g. trawling and mining), are reported to the WDPA and do not meet these standards, inflating progress toward conservation targets. The extent of Australian Marine Parks, for instance, is 2,762,831 km^2 (approximately 34% of the total EEZ) based on MPA areas reported in 2018 management plans [24,26,28,30,32]. If areas in which industrial-scale activity is authorized were no longer reported as MPAs, in line with IUCN guidelines [54], the area coverage of Australian Marine Parks would instead be 622,981 km^2 (approximately 8% of the total EEZ). (See Supplementary Text, Methods and Results Tables 2-3). Monitoring PADDD events and highlighting those that authorize expansion of industrial-scale activity, as was done here, can support more accurate reporting toward MPA targets in line with global standards.

National-level policies and processes also provide opportunities to address PADDD and minimize its impacts [51]. MPA permanence could be improved through PADDD processes that parallel PA establishment, and include public consultation, visual representations of PADDD proposals, and environmental impact studies [49]. The mitigation hierarchy (avoidance, minimization, restoration, and offsetting) [55] could help guide negotiations surrounding PADDD proposals [13,51]. Policies that prohibit environmentally damaging PADDD in priority conservation sites or 'No-Go Areas' (e.g. World Heritage marine sites) or for proximate causes that undermine marine conservation goals (e.g. mining) could be enacted to avoid impacts of PADDD [51,56]. Laws could require that legislation establishing MPAs contain comprehensive restrictions on industrial-scale activities, preventing potential loopholes such as those that allowed dredge spoil dumping in the Great Barrier Reef Marine Park [57]. Public and private funders could recognize the impermanence of PAs in safeguard policies and ensure that PADDD is not incentivized in funding decisions [13]. Finally, additional long-term funding is needed to reach protected area targets and ensure adequate PA management [58], potentially improving PA durability and decreasing the likelihood of PADDD.

5. Conclusion

As global demand for marine resources increases [59], debates related to PADDD are likely to intensify [14,16]. Though incomplete, this preliminary study provides a foundation for future analyses and adds to growing evidence of PADDD upon which initial policy responses can be developed. While this analysis highlights potential limitations of MPAs and other area-based conservation strategies, it does not lessen their importance in global efforts to conserve biodiversity [14,60], mitigate climate change [61], and when well-designed and managed, support sustainable livelihoods [62]. Rather, findings underscore the need for further research and proactive policy responses to address PADDD and sustain durable and effective MPAs. Addressing this need will help safeguard ocean health over the long-term for the benefit of marine biodiversity and the people who depend upon it.

Acknowledgements

Renee Albrecht, Michael B. Mascia, and Rachel E. Golden Kroner received support from Gordon and Betty Moore. C.N. Cook was funded by an Ian Potter Foundation Science Grant, and an ARC Discovery Early Career Researcher Fellowship (DE180100845). We would like to thank Angelo Villagomez for insights that helped guide this manuscript and Yifan (Flora) He for her support with data collection and analysis.

References

[1] Millennium Ecosystem Assessment (Program), Ecosystems and human well-being: synthesis, Island Press, Washington, DC, 2005.

[2] J.M. Hall-Spencer, B.P. Harvey, Ocean acidification impacts on coastal ecosystem services due to habitat degradation, Emerging Topics in Life Sciences. 3 (2019) 197–206. https://doi.org/10.1042/ETLS20180117.

[3] B.S. Halpern, M. Frazier, J. Potapenko, K.S. Casey, K. Koenig, C. Longo, J.S. Lowndes, R.C. Rockwood, E.R. Selig, K.A. Selkoe, S. Walbridge, Spatial and temporal changes in cumulative human impacts on the world’s ocean, Nat Commun. 6 (2015) 7615. https://doi.org/10.1038/ncomms8615.

[4] D.A. Smale, T. Wernberg, E.C.J. Oliver, M. Thomsen, B.P. Harvey, S.C. Straub, M.T. Burrows, L.V. Alexander, J.A. Benthuysen, M.G. Donat, M. Feng, A.J. Hobday, N.J. Holbrook, S.E. Perkins-Kirkpatrick, H.A. Scannell, A. Sen Gupta, B.L. Payne, P.J. Moore, Marine heatwaves threaten global biodiversity and the provision of ecosystem services, Nat. Clim. Chang. 9 (2019) 306–312. https://doi.org/10.1038/s41558-019-0412-1.

[5] B. Worm, E.B. Barbier, N. Beaumont, J.E. Duffy, C. Folke, B.S. Halpern, J.B.C. Jackson, H.K. Lotze, F. Micheli, S.R. Palumbi, E. Sala, K.A. Selkoe, J.J. Stachowicz, R. Watson, Impacts of Biodiversity Loss on Ocean Ecosystem Services, Science. 314 (2006) 787–790. https://doi.org/10.1126/science.1132294.

[6] C.J. Klein, C.J. Brown, B.S. Halpern, D.B. Segan, J. McGowan, M. Beger, J.E.M. Watson, Shortfalls in the global protected area network at representing marine biodiversity, Sci Rep. 5 (2015) 17539. https://doi.org/10.1038/srep17539.

[7] E. Sala, S. Giakoumi, No-take marine reserves are the most effective protected areas in the ocean, ICES Journal of Marine Science. 75 (2018) 1166–1168. https://doi.org/10.1093/icesjms/fsx059.

[8] CBD (Convention on Biological Diversity), Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at Its Tenth Meeting [Decision X/2] Nagoya, Aichi Prefecture, Japan, (2010).

[9] United Nations, Sustainable Development Goal 14, Sustainable Development Goals Knowledge Platform. (n.d.). https://sustainabledevelopment.un.org/sdg14 (accessed April 28, 2020).

[10] E. Dinerstein, C. Vynne, E. Sala, A.R. Joshi, S. Fernando, T.E. Lovejoy, J. Mayorga, D. Olson, G.P. Asner, J.E.M. Baillie, N.D. Burgess, K. Burkart, R.F. Noss, Y.P. Zhang, A. Baccini, T. Birch, N. Hahn, L.N. Joppa, E. Wikramanayake, A Global Deal For Nature: Guiding principles, milestones, and targets, Sci. Adv. 5 (2019) eaaw2869. https://doi.org/10.1126/sciadv.aaw2869.

[11] Increasing marine protected area coverage for effective marine biodiversity conservation, (2016). https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_050_EN.pdf (accessed June 30, 2020).

[12] UNEP-WCMC, IUCN and NGS, Protected Planet Live Report 2020, UNEP-WCMC, IUCN and NGS, Cambridge UK; Gland, Switzerland; and Washington, D.C., USA, 2020. (accessed October 5, 2020).

[13] R.E. Golden Kroner, S. Qin, C.N. Cook, R. Krithivasan, S.M. Pack, O.D. Bonilla, K.A. Cort-Kansinally, B. Coutinho, M. Feng, M.I. Martínez Garcia, Y. He, C.J. Kennedy, C. Lebreton, J.C. Ledezma, T.E. Lovejoy, D.A. Luther, Y. Parmanand, C.A. Ruíz-Agudelo, E. Yerena, V. Morón Zambrano, M.B. Mascia, The uncertain future of protected lands and waters, Science. 364 (2019) 881–886. https://doi.org/10.1126/science.aau5525.

[14] M.B. Mascia, S. Pailler, Protected area downgrading, downsizing, and degazettement (PADDD) and its conservation implications: PADDD and its implications, Conservation Letters. 4 (2011) 9–20. https://doi.org/10.1111/j.1755-263X.2010.00147.x.

[15] C.N. Cook, R.S. Valkan, M.B. Mascia, M.A. McGeoch, Quantifying the extent of protected-area downgrading, downsizing, and degazettement in Australia: Dynamics of Protected Areas, Conservation Biology. 31 (2017) 1039–1052. https://doi.org/10.1111/cobi.12904.
[16] M.B. Mascia, S. Pailler, R. Krithivasan, V. Roshchanka, D. Burns, M.J. Mlotha, D.R. Murray, N. Peng, Protected area downgrading, downsizing, and degazettement (PADDD) in Africa, Asia, and Latin America and the Caribbean, 1900–2010, Biological Conservation. 169 (2014) 355–361. https://doi.org/10.1016/j.biocon.2013.11.021.
[17] K.E. Roberts, R.S. Valkan, C.N. Cook, Measuring progress in marine protection: A new set of metrics to evaluate the strength of marine protected area networks, Biological Conservation. 219 (2018) 20–27. https://doi.org/10.1016/j.biocon.2018.01.004.
[18] A. Grech, G.J. Edgar, P. Fairweather, R.L. Pressey, T.J. Ward, Australian marine protected areas, in: A. Stow, N. Maclean, G.I. Holwell (Eds.), Austral Ark, Cambridge University Press, Cambridge, 2014: pp. 582–599. https://doi.org/10.1017/CBO9781139519960.029.
[19] Parks Australia, Australian Marine Parks. (2019). https://parksaustralia.gov.au/marine/parks/ (accessed December 15, 2019).
[20] M. Mascia, S. Pailler, R. Krithivasan, PADDDtracker.org Technical Guide (Version 1), (2012).
[21] M. Mascia, S. Pailler, R. Krithivasan, S. Qin, R. Albrecht, R.E. Golden Kroner, PADDDtracker.org Technical Guide (Version 2), (2020).
[22] K.E. Roberts, O. Hill, C.N. Cook, Evaluating perceptions of marine protection in Australia: Does policy match public expectation?, Marine Policy. 112 (2020) 103766. https://doi.org/10.1016/j.marpol.2019.103766.
[23] Director of National Parks, Coral Sea Commonwealth Marine Reserve Management Plan 2014–24, Director of National Parks, Canberra, 2013.
[24] Director of National Parks, Coral Sea Marine Park Management Plan 2018, Director of National Parks, Canberra, 2018.
[25] Director of National Parks, North Commonwealth Marine Reserves Network Management Plan 2014-24, Director of National Parks, Canberra, 2013.
[26] Director of National Parks, North Marine Parks Network Management Plan 2018, Director of National Parks, Canberra, 2018.
[27] Director of National Parks, North-west Commonwealth Marine Reserves Network Management Plan 2014-24, Director of National Parks, Canberra, 2013.
[28] Director of National Parks, North-west Marine Parks Network Management Plan 2018, Director of National Parks, Canberra, 2018.
[29] Director of National Parks, South-west Commonwealth Marine Reserves Network Management Plan 2014-24, Director of National Parks, Canberra, 2013.
[30] Director of National Parks, South-west Marine Parks Network Management Plan 2018, Director of National Parks, Canberra, 2018.
[31] Director of National Parks, Temperate East Commonwealth Marine Reserves Network Management Plan 2014– 24, Director of National Parks, Canberra, 2013.
[32] Director of National Parks, Temperate East Marine Parks Network Management Plan 2018, Director of National Parks, Canberra, 2018.
[33] Australian Government Department of Agriculture, Water and the Environment, Australian Marine Parks, Commonwealth of Australia, Australian Government Department of the Environment and Energy, Canberra, 2018. http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BCD8877F3-8C39-4A20-A53F-070FBEE5AF3C%7D.
[34] Collaborative Australian Protected Areas Database (CAPAD) 2016, (n.d.). http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B57645456-C5D3-483C-89F4-51A0EC6070EC%7D (accessed January 16, 2020).

[35] Decision on fishing amnesty announced, NSW Environment, Energy and Science. (2014). http://www.environment.nsw.gov.au/news/decision-on-fishing-amnesty-announced (accessed July 1, 2020).
[36] J.L. Forrest, M.B. Mascia, S. Pailler, S.Z. Abidin, M.D. Araujo, R. Krithivasan, J.C. Riveros, Tropical Deforestation and Carbon Emissions from Protected Area Downgrading, Downsizing, and Degazettement (PADDD): Deforestation from PADDD, CONSERVATION LETTERS. 8 (2015) 153–161. https://doi.org/10.1111/conl.12144.
[37] G.J. Edgar, R.D. Stuart-Smith, T.J. Willis, S. Kininmonth, S.C. Baker, S. Banks, N.S. Barrett, M.A. Becerro, A.T.F. Bernard, J. Berkhout, C.D. Buxton, S.J. Campbell, A.T. Cooper, M. Davey, S.C. Edgar, G. Försterra, D.E. Galván, A.J. Irigoyen, D.J. Kushner, R. Moura, P.E. Parnell, N.T. Shears, G. Soler, E.M.A. Strain, R.J. Thomson, Global conservation outcomes depend on marine protected areas with five key features, Nature. 506 (2014) 216–220. https://doi.org/10.1038/nature13022.
[38] G.J. Edgar, T.J. Ward, R.D. Stuart-Smith, Rapid declines across Australian fishery stocks indicate global sustainability targets will not be achieved without an expanded network of 'no-fishing' reserves, Aquatic Conserv: Mar Freshw Ecosyst. 28 (2018) 1337–1350. https://doi.org/10.1002/aqc.2934.
[39] C.D. Kuempel, K.R. Jones, J.E.M. Watson, H.P. Possingham, Quantifying biases in marine-protected-area placement relative to abatable threats, Conservation Biology. 33 (2019) 1350–1359. https://doi.org/10.1111/cobi.13340.
[40] R. Pollnac, P. Christie, J.E. Cinner, T. Dalton, T.M. Daw, G.E. Forrester, N.A.J. Graham, T.R. McClanahan, Marine reserves as linked social-ecological systems, Proceedings of the National Academy of Sciences. 107 (2010) 18262–18265. https://doi.org/10.1073/pnas.0908266107.
[41] D.A. Gill, M.B. Mascia, G.N. Ahmadia, L. Glew, S.E. Lester, M. Barnes, I. Craigie, E.S. Darling, C.M. Free, J. Geldmann, S. Holst, O.P. Jensen, A.T. White, X. Basurto, L. Coad, R.D. Gates, G. Guannel, P.J. Mumby, H. Thomas, S. Whitmee, S. Woodley, H.E. Fox, Capacity shortfalls hinder the performance of marine protected areas globally, Nature. 543 (2017) 665–669. https://doi.org/10.1038/nature21708.
[42] W.S. Symes, M. Rao, M.B. Mascia, L.R. Carrasco, Why do we lose protected areas? Factors influencing protected area downgrading, downsizing and degazettement in the tropics and subtropics, Glob Change Biol. 22 (2016) 656–665. https://doi.org/10.1111/gcb.13089.
[43] A.T. Tesfaw, A. Pfaff, R.E. Golden Kroner, S. Qin, R. Medeiros, M.B. Mascia, Land-use and land-cover change shape the sustainability and impacts of protected areas, Proc Natl Acad Sci USA. 115 (2018) 2084–2089. https://doi.org/10.1073/pnas.1716462115.
[44] D.A. Miteva, B.C. Murray, S.K. Pattanayak, Do protected areas reduce blue carbon emissions? A quasi-experimental evaluation of mangroves in Indonesia, Ecological Economics. 119 (2015) 127–135. https://doi.org/10.1016/j.ecolecon.2015.08.005.
[45] D.C. Dunn, C. Jablonicky, G.O. Crespo, D.J. McCauley, D.A. Kroodsma, K. Boerder, K.M. Gjerde, P.N. Halpin, Empowering high seas governance with satellite vessel tracking data, Fish Fish. 19 (2018) 729–739. https://doi.org/10.1111/faf.12285.
[46] E.R. Selig, W.R. Turner, S. Troëng, B.P. Wallace, B.S. Halpern, K. Kaschner, B.G. Lascelles, K.E. Carpenter, R.A. Mittermeier, Global Priorities for Marine Biodiversity Conservation, PLoS ONE. 9 (2014) e82898. https://doi.org/10.1371/journal.pone.0082898.
[47] G.R. McDermott, K.C. Meng, G.G. McDonald, C.J. Costello, The blue paradox: Preemptive overfishing in marine reserves, Proc Natl Acad Sci USA. 116 (2019) 5319–5325. https://doi.org/10.1073/pnas.1802862115.
[48] D. Keles, P. Delacote, A. Pfaff, S. Qin, M.B. Mascia, What Drives the Erasure of Protected Areas? Evidence from across the Brazilian Amazon, Ecological Economics. 176 (2020) 106733. https://doi.org/10.1016/j.ecolecon.2020.106733.
[49] S.M. Pack, M.N. Ferreira, R. Krithivasan, J. Murrow, E. Bernard, M.B. Mascia, Protected area downgrading, downsizing, and degazettement (PADDD) in the Amazon, Biological Conservation. 197 (2016) 32–39. https://doi.org/10.1016/j.biocon.2016.02.004.

[50] E. Bacon, P. Gannon, S. Stephen, E. Seyoum-Edjigu, M. Schmidt, B. Lang, T. Sandwith, J. Xin, S. Arora, K.N. Adham, A.J.R. Espinoza, M. Qwathekana, A.P.L. Prates, A. Shestakov, D. Cooper, J. Ervin, B.F. de S. Dias, B. Leles, M. Attallah, J. Mulongoy, S.B. Gidda, Aichi Biodiversity Target 11 in the like-minded megadiverse countries, Journal for Nature Conservation. 51 (2019) 125723. https://doi.org/10.1016/j.jnc.2019.125723.

[51] S. Qin, R.E. Golden Kroner, C. Cook, A.T. Tesfaw, R. Braybrook, C.M. Rodriguez, C. Poelking, M.B. Mascia, Protected area downgrading, downsizing, and degazettement as a threat to iconic protected areas, Conservation Biology. 33 (2019) 1275–1285. https://doi.org/10.1111/cobi.13365.

[52] S.M. Maxwell, K.M. Gjerde, M.G. Conners, L.B. Crowder, Mobile protected areas for biodiversity on the high seas, Science. 367 (2020) 252–254. https://doi.org/10.1126/science.aaz9327.

[53] Scientist Support for 30% by 2030, Marine Conservation Institute. (2020). https://marine-conservation.org/30x30-support/ (accessed June 2, 2020).

[54] J. Day, N. Dudley, M. Hockings, G. Holmes, D. Laffoley, S. Stolton, S. Wells, L. Wenzel, Guidelines for applying the IUCN Protected Area Management Categories to Marine Protected Areas., Gland, Switzerland: IUCN, 2019.

[55] K. ten Kate, M. Crowe, Biodiversity offsets: policy options for governments., International Union for Conservation of Nature, Gland, Switzerland, 2014.

[56] IUCN, Motion 026 - protected areas and other areas important for biodiversity in relation to environmentally damaging industrial activities and infrastructure development., (2016).

[57] B. Smee, Great Barrier Reef authority gives green light to dump dredging sludge, The Guardian. (2019). https://www.theguardian.com/environment/2019/feb/20/great-barrier-reef-authority-gives-green-light-to-dump-dredging-sludge (accessed September 16, 2020).

[58] A. Waldron, V. Adams, J. Allan, A. Arnell, G. Asner, S. Atkinson, A. Baccini, E. Baillie, A. Balmford, J.A. Beau, L. Brander, E. Brondizio, A. Bruner, N. Burgess, K. Burkart, S. Butchart, R. Button, R. Carrasco, W. Cheung, V. Christensen, A. Clements, M. Coll, di Marco, M. Deguignet, E. Dinerstein, E. Ellis, F. Eppink, J. Ervin, A. Escobedo, J. Fa, A. Fernandes-Llamazares, S. Fernando, S. Fujimori, B. Fulton, S. Garnett, J. Gerber, D. Gill, T. Gopalakrishna, N. Hahn, B. Halpern, T. Hasegawa, P. Havlik, V. Heikinheimo, R. Heneghan, E. Henry, F. Humpenoder, H. Jonas, K. Jones, L. Joppa, A.R. Joshi, N. Kingston, C. Klein, T. Krisztin, V. Lam, D. Leclere, P. Lindsey, H. Locke, T. Lovejoy, P. Madgwick, Y. Malhi, P. Malmer, M. Maron, J. Mayorga, H. van Meijl, D. Miller, Z. Molnar, N. Mueller, N. Mukherjee, R. Naidoo, K. Nakamura, P. Nepal, R. Noss, B. O'Leary, D. Olson, J.P. Abrantes, M. Paxton, A. Popp, H. Possingham, J. Prestemon, J. Steenbeck, E. Stehfest, B. Strassborg, R. Sumaila, K. Swinnerton, J. Sze, D. Tittensor, T. Toivonen, A. Toledo, P.N. Torres, T. Vilela, P. Visconti, C. Vynne, R. Watson, J. Watson, E. Wikramanayake, B. Williams, B. Wintle, S. Woodley, W. Wu, K. Zander, Y. Zhang, Y. Zhang, Protecting 30% of the planet for nature: costs, benefits and economic implications, (2020) 58.

[59] G. Merino, M. Barange, J.L. Blanchard, J. Harle, R. Holmes, I. Allen, E.H. Allison, M.C. Badjeck, N.K. Dulvy, J. Holt, S. Jennings, C. Mullon, L.D. Rodwell, Can marine fisheries and aquaculture meet fish demand from a growing human population in a changing climate?, Global Environmental Change. 22 (2012) 795–806. https://doi.org/10.1016/j.gloenvcha.2012.03.003.

[60] K.R. Jones, C.J. Klein, H.S. Grantham, H.P. Possingham, B.S. Halpern, N.D. Burgess, S.H.M. Butchart, J.G. Robinson, N. Kingston, N. Bhola, J.E.M. Watson, Area Requirements to Safeguard Earth's Marine Species, One Earth. 2 (2020) 188–196. https://doi.org/10.1016/j.oneear.2020.01.010.

[61] C.M. Roberts, B.C. O'Leary, D.J. McCauley, P.M. Cury, C.M. Duarte, J. Lubchenco, D. Pauly, A. Sáenz-Arroyo, U.R. Sumaila, R.W. Wilson, B. Worm, J.C. Castilla, Marine reserves can mitigate and promote adaptation to climate change, Proc Natl Acad Sci USA. 114 (2017) 6167–6175. https://doi.org/10.1073/pnas.1701262114.

[62] J.-Y. Weigel, K.O. Mannle, N.J. Bennett, E. Carter, L. Westlund, V. Burgener, Z. Hoffman, A. Simão Da Silva, E.A. Kane, J. Sanders, C. Piante, S. Wagiman, A. Hellman, Marine protected areas and fisheries: bridging the divide: MPAS & FISHERIES: BRIDGING THE DIVIDE, Aquatic Conserv: Mar. Freshw. Ecosyst. 24 (2014) 199–215. https://doi.org/10.1002/aqc.2514.