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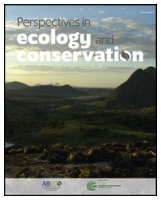

Essays and Perspectives

Hope and doubt for the world's marine ecosystems

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ABSTRACT

In June 5–9, 2017, during the United Nations (UN) Ocean Conference, 143 governments, signatory parties of the Convention on Biological Diversity (CBD) declared their commitment and strategies to reach several objectives of the Sustainable Development Goal (SDG) 14, which stands to "conserve and sustainably use the oceans, seas and marine resources for sustainable development". In a relatively short time frame, the parties have committed to develop marine spatial planning, enforce sustainable management and protection of marine ecosystems, conserve at least 10% of the world's marine habitats, end overfishing, provide access for small-scale fishers, reduce marine pollution and ocean acidification, among others ambitious goals. The ocean has been included in the Paris Agreement, the subsequent Global Climate Action Agenda in 2015, and the 23rd Conference of the Parties of the UN (COP23), held in November 2017, which has assessed the global progress toward the SDG14, organizing several action plans. The UN seems optimistic with the progress achieved towards SDG 14, suggesting that overfishing has slowed down in the past 10 years and that over 8.4% of the world's exclusive economic zones are under protection. However, only a small fraction of that is under strong protection and many priority areas are still unprotected. In addition, major challenges presented by signatory governments are slowing down or compromising the achievement of the 14 SDG targets. Despite the challenges, we envision hope towards the sustainability of the world's marine biodiversity, where managers, scientists, and stakeholders work together to defend biodiversity, ecosystem services, and resources that the world depends on.

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During the 2017 UN Ocean Conference, many governments have recommitted to reach several objectives of the Sustainable Development Goal (SDG) 14. As product of the conference, nations worldwide presented their plans to develop marine spatial planning, sustainably manage marine ecosystems, conserve at least 10% of the world's marine habitats, end overfishing, provide access for small-scale fishers, reduce marine pollution and ocean acidification, among others ambitious goals, most of them to be achieved by 2020. The UN seems optimistic with the progress achieved towards SDG 14. However, here we review the 14 SDG targets and indicators, showing many challenges and flaws that are slowing down or compromising their achievement.

Marine Protected Areas coverage

One of the most debated and questioned targets of the SDG 14 (Barnes et al., 2018; O'Leary et al., 2018; Roberts et al., 2018; Rocha, 2018) focuses on the conservation of at least 10% of coastal and marine areas, based on the best available scientific information, and through an effectively managed, ecologically representative and well-connected system of Marine Protected Areas (MPAs) by 2020. Research on marine spatial planning has advanced quickly (Pınarbaşı et al., 2017), but despite this progress, few countries have adopted this approach to implement comprehensive networks of MPAs. In a wave of political opportunity, many signatory countries have recently created new MPAs and/or expanded already established ones covering thousands of km^2 of open ocean. This strategy of establishing relatively large protected areas in remote regions with low conflict among resource users seems to follow a trend that has already occurred on land (Devillers et al., 2015). Consequently, over 8.4% of the world's exclusive economic zones (EEZ) are under

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some sort of protection (Day et al., 2015). But this number is closer to 2% if only areas with effective enforcement and management are considered (Sala et al., 2018). To make matters worse, the current level of protection does not differ significantly from a scenario in which MPAs were placed at random across the oceans, leaving many high priority areas unprotected (Lindegren et al., 2018). In addition, the current race to reach a simple area target has the potential to bring about perverse outcomes to marine conservation if the places and species that are most at risk don't receive protection (Barnes et al., 2018). For example, most governments are failing to protect the diversity of marine ecosystems equitably, leaving threatened and highly biodiverse coastal ecosystems, which often bring with them high conflict among resource users, unprotected (Jones and De Santo, 2016). Worrisomely, the United Nations has in some instances agreed with this uneven conservation strategy by ratifying flawed target achievements that favor the protection of low conflict and low diversity areas (United Nations, 2018).

Fully protected MPAs are recognized worldwide as one of the most effective tools for biodiversity conservation. Large MPAs have the potential to protect not only biodiversity, but also oceanographic, ecological and evolutionary processes. However, they need to assure adequate biodiversity and ecosystem representation, connectivity and persistence over ecological and evolutionary time scales. Those criteria are not met by most large MPAs, such as those recently created in Brazil, Chile, Mexico, the Seychelles, and the U.K., which cover thousands of km^2 of a single habitat (open ocean) (Giglio et al., 2018; Jones and De Santo, 2016; Rocha, 2018). Many of these MPAs allow local fisheries in over-exploited and highly biodiverse habitats to continue unchanged, including coral reefs, sandy beaches, mangroves and rocky shores (Giglio et al., 2018; Rocha, 2018). The application of this simple area-based approach unevenly protecting the open ocean gives a wrong sense of achieving adequate conservation, and is often counterproductive (Barnes et al., 2018). Although the protection of open water environments should be considered an advance, without reduction in global fishing effort, the highly migratory animals found in this ecosystem remain threatened (Hilborn, 2016), being fished at the same rates outside of the MPAs' borders (Kroodsma et al., 2018; Tickler et al., 2018).

Sustainably manage and protect marine and coastal ecosystems

Another SDG 14 target aims to manage marine ecosystems using ecosystem-based approaches. However, while this new trend of establishing large MPAs in the open ocean is quickly spreading, the implementation and management of coastal protected areas usually takes decades, and many conservation initiatives end up being suppressed by well-funded development projects such as oil and gas exploration, and port construction (Box 1). In some extreme cases, in order to accommodate large coastal projects, MPAs are decommissioned or have their areas altered to fit the developmental agenda (Box 1). Failure to protect coastal habitats will likely cause the extinction of entire ecosystems, as many ecological and evolutionary processes occur across the continental shelf, with coastal habitats generally functioning as nurseries. Many ecosystems in developing countries, such as China, are already highly transformed, completely exploited, and pushed into a new normal (see Zhang et al., 2016), with few natural resources remaining to be sustainably exploited.

It is a reality that in both developed and developing countries, environmental managers and scientists are working hard to evaluate and implement MPAs and other management tools. However, conservation projects are colliding with large economic forces and governments (Driscoll et al., 2018), which envisage a fast, although ephemeral and unequally distributed, monetary advantage. This economic pressure threatens even well-established MPAs in developed countries. In Australia, for example, a country committed to enforce their MPAs, a proposal that nearly halves the level of protection in many places of the Great Barrier Reef was recently approved (Reese, 2017). Jointly back paddling, the USA government, which is not a CBD signatory, but holds large MPAs, has imposed a halt on the creation of new marine sanctuaries and recommended to modify and shrink boundaries as well as to remove protections against mining in MPAs such as Northeast Canyons and Seamounts, Pacific Remote Islands, and Rose Atoll marine national monuments.

Therefore, there is a general need for coordination between environmental and developmental agencies in order to establish adequate coastal management strategies. Environmental managers and scientists need to find a better approach to the selection of natural areas that might be suppressed or modified by coastal development; while development agencies need to stop ignoring the necessity for areas to be reserved for sustainable use, as well as fully protected areas to preserve ecosystem services and hotspots of biodiversity and endemism. The United Nations needs to review their indicators (Driscoll et al., 2018), assessing the quality of achievements, real protection and ecosystem representativeness (Barnes et al., 2018). Our end goal should be to effectively conserve threatened and highly biodiverse regions, ecosystems, and species. Currently, progress towards Aichi target 11 is not moving us closer to that goal (Driscoll et al., 2018). Therefore, we suggest that a target percent area, which invariably results in a political rush to protect low-conflict and low-use areas, is dropped. Instead, targets should shift to focus on the protection of the highest number of species and ecosystems (and/or other attributes such as endemism, occurrence of endangered species, ecosystem services) on highly threatened areas.

Effectively regulate harvesting and end overfishing

Many SDG 14 targets are connected to or dependent on the implementation of sustainable fisheries management (e.g., 14.2, 14.4, 14.5, 14.6, 14.7, 14.B and 14.C), which is part of the agenda of most countries. The UN suggests that overfishing has slowed down in the past 10 years. UN's main objective is to end overfishing and

Box 1

The conflict between marine conservation and development strategies in Brazil, a study case.

Many proposals of marine protected areas (MPAs) with advanced level of studies and community involvement are taking over a decade to be established (Fig. 1A). In these priority areas for conservation and sustainable development, destructive mining and port projects are being approved and installed much faster than the MPAs.

Prior approval, the local government forced changes in the limit of a recently created MPA to accommodate an industrial port complex (Fig. 1B; dashed yellow line indicates previously proposed limit). Note that this region also presents conflict between conservation and development projects.

Fig. 1C highlights Abrolhos Bank, the largest coral reef complex in the South Atlantic, which was suggested to become a mosaic of MPAs. The buffering zone of Abrolhos National Park (established since 1989), now a large sustainable use MPA proposal encompassing the bank, was decommissioned to accommodate oil and mining projects at the south of the bank. These very large MPA proposals for Abrolhos were presented in the RIO + 20 summit lacking a systematic planning and communication with stakeholders. Consequently the proposal did not have the support from state governments and fisheries organizations, quickly falling apart.

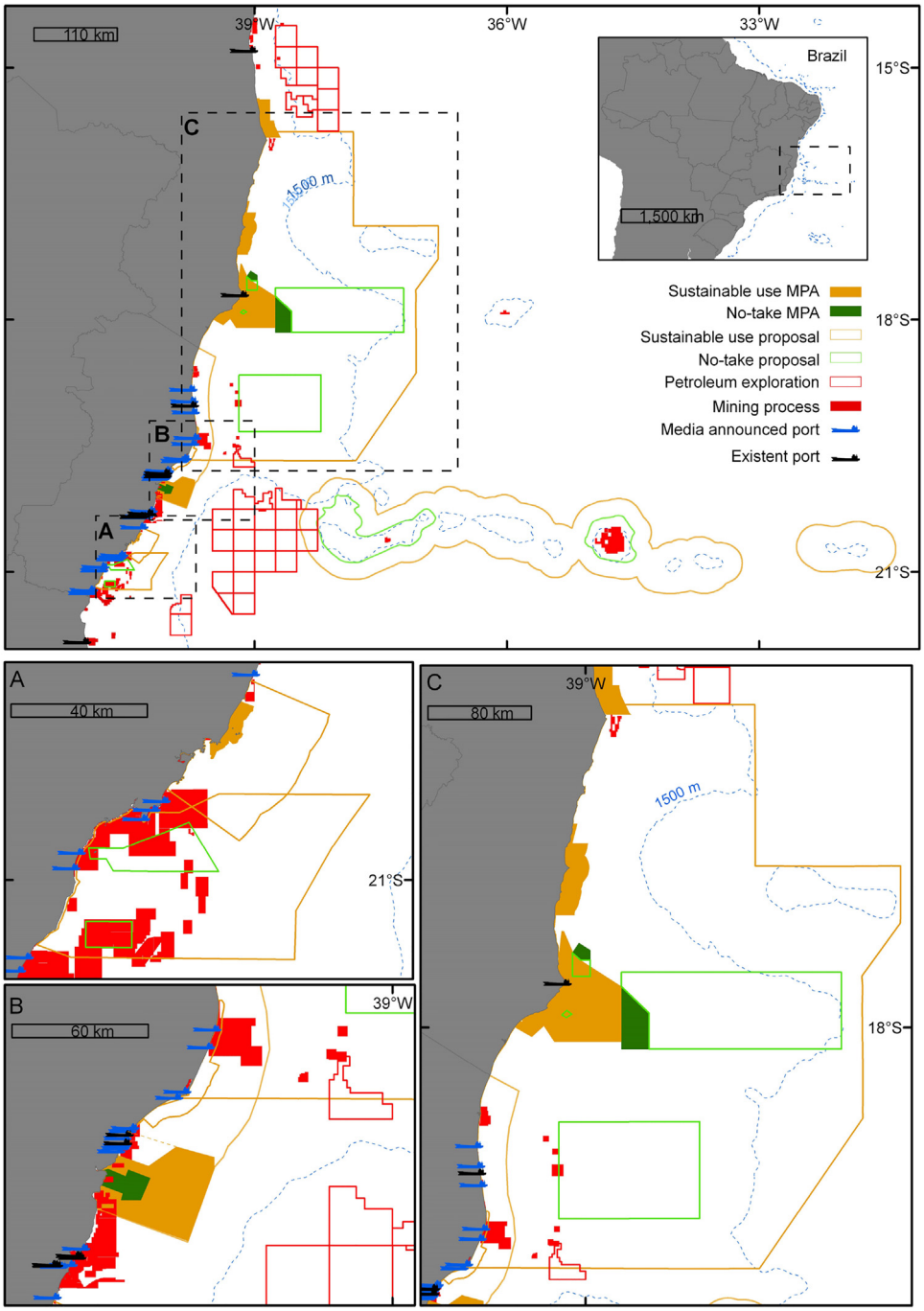

Fig. 1. Examples of conflict between marine conservation and development strategies in the central coast of Brazil.

increase support for small-scale fisheries, such as the artisanal and traditional ones, widely recognized as small-scale, low-technology, and low-capital activities. However, the political scenario of most countries favors large-scale and industrial fisheries. Many Pacific Island nations issue concessions of their exclusive economic zones (EEZ) to large-scale factory ships (FAO, 2002; Wilson, 2007) (Box 2). The African coast is targeted by illegal industrial vessels coming mainly from Europe, Russia and China (Doumbouya et al., 2017; Greenpeace, 2015; Tickler et al., 2018). In Brazil for example, boats of up to 20 tons are now classified as "artisanal vessels", while benefits for true small-scale traditional fishers are becoming increasingly more scarce (Pinheiro et al., 2015). India is on the same wrong track, with the country committed to supply relatively large fishing boats to originally artisanal fishers to promote deep-sea fishing as a "sustainable" fishing strategy, although fishing down to greater depths is likely as unsustainable as fishing down the food web (Pauly et al., 1998). Countries holding large industrial fleets (such as China, Japan, and Spain) did not commit to changing fishing techniques and stop overfishing. On the contrary, they have greatly increased their distance of operation in the last six decades (Tickler et al., 2018). Thus, financial support and access for sustainable small-scale artisanal fishers will be extremely challenging, as such measures go against the current government policy of many countries.

The best alternatives for the future of artisanal fishers involve a more integrative management, with the establishment of traditional fishing territories and enforcement of sustainable use MPAs, banning industrial vessels and disrupting the unfair

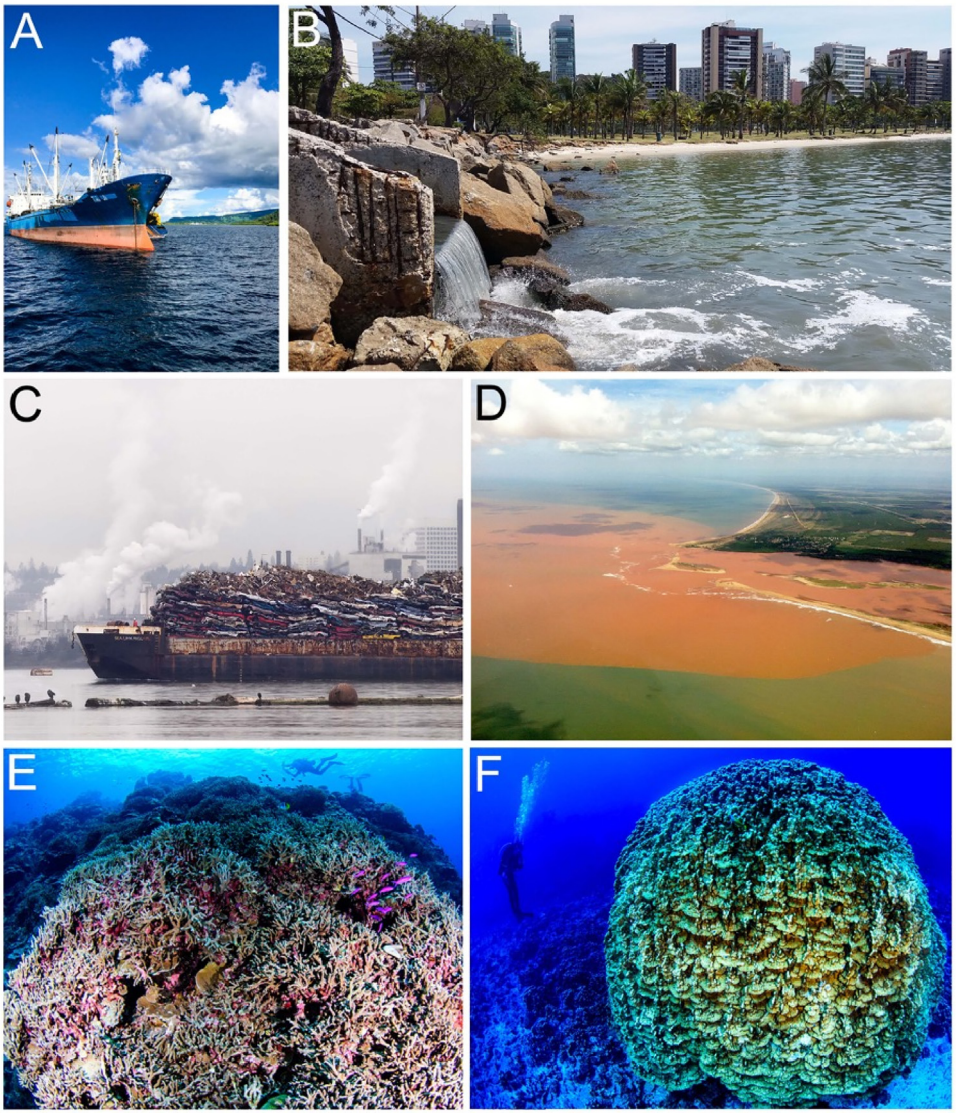

Fig. 2. Doubts and hope for the world's marine biodiversity. Photos by Luiz A. Rocha, Felipe Buloto, Ingrid Taylar and Eric Mazzei.

competition. Subsistence and indigenous fishers need to be included in decision making, enforcement and management planning, in order to maximize sustainable development and social benefits, and decrease conflicts. However, as in many of these countries a large proportion of fishing stocks are already collapsed, there is also the need for social and economic assistance to seek livelihood alternatives for fishers that no longer have access to exploitable fishing stocks. Moreover, the relationship between managers and fishers is hardly amicable, mainly when dealing with over-exploited and threatened resources. For example, Brazil is committed to protect 100% of its threatened species by 2020 through at least one conservation instrument. Despite such commitment, the Brazilian red list of marine endangered species, which was published in 2014, has been revoked several times due to political pressure from the fisheries lobby (both industrial and small-scale, Pinheiro et al., 2015). The Federal Government announced a modification of the red list on 19 June 2017, allowing the capture and trade of most vulnerable species. Some developed countries, such as the US, are also relaxing their endangered species policy, instead of enforcing it, favoring exploitation and unsustainable uses. These policies broaden the distance between fishers, managers and scientists, making joint action toward sustainable fisheries difficult.

Prevent and significantly reduce marine pollution

Marine pollution, especially plastics, is an increasing threat for the world marine biodiversity and many governments want to develop and launch national plans to combat these issues. However, most developing countries suffer from untreated sewage discharge in water bodies. For example, 60% of the sewage production in Brazil is released untreated in the environment (Box 2), while over 80% is discharged untreated in India, and up to 90% in China. These three countries combined make up 25% of the Earth's population. Pollution is also a concern for developed countries, with the number and extension of dead zones increasing around the world, particularly at river mouths and nearby continental shelves (Diaz and Rosenberg, 2008). Plastic waste, although gaining global concern just recently, is another serious problem with long-term contamination of the oceans. In 2010 alone, between 4.8 and 12.7 million metric tons of plastic entered the oceans (Jambeck et al., 2015), with microplastics as the major contributor in terms of plastic numbers (Worm et al., 2017). Five CBD signatory countries are responsible for almost 60% of this pollution (Ocean Conservancy, 2015).

Moreover, thousands of ports and shipyards widespread along the world's coastline constantly dump dredged contaminated sediments over marine natural environments (Buruaem et al., 2012)

Box 2

Doubts

(A) Fishing factory-ship harbored in Pohnpei, Micronesia. Hundreds of Asian factory-ships are commissioned to fish in the Micronesia. This large-scale fishing activity threatens Pacific pelagic species, minimizing possibilities for local sustainable development. (B) Untreated sewage discharge in the wealthiest neighborhood of Vitória, Brazil. Eutrophication, one of the main drivers of marine community changes, is a problem in both developed and undeveloped countries. The spread of dead zones in coastal regions is compromising important ecosystem services such as nursery zones. (C) Port of Tacoma, USA. Dredged sediments, removed periodically from ports, are normally dumped in coastal waters, suppressing natural environments. The suspension of sediments usually containing high levels of heavy metals has strong potential to contaminate the food chain. (D) Worst environmental disaster in Brazil: toxic "mud-tsunami", from a Rio Doce mining dam collapse, reaching the Atlantic Ocean. Thousands of other dams are in the same precarious situation.

There is hope

(E) Coral Reefs in Palau are healthy and are considered the main source of sustainable activities such as tourism and local fishing. (F) Coral reefs around Easter Island, Chile, still unprotected, now have a chance to be integrated to the recently created MPA, which focus on pelagic areas with low fishing effort. In Brazil, the interaction among managers, scientists and the military is allowing the implementation of fisheries management in high biodiversity and endemism areas that ended up outside the borders of the recently created large MPAs.

(Box 2). At the same time, while ship traffic increases, environmental laws regulating such traffic are losing power globally due political instability. Recently, Brazil experienced its worst environmental disaster due to an iron mining dam collapse at the Doce River that reached the ocean (Box 2): heavy metal rates in shrimp and fishes reached up to 100x higher than values allowed by regional regulations (Bianchini, 2016). So far nothing has been done to avoid new accidents like this in the future, and locals are still using contaminated water for irrigation and keep harvesting aquatic resources. Near 350 other mining dams, in just one Brazilian state, have their structures compromised, with high risk of collapse (Fernandes et al., 2016). However, instead of taking action towards regulating highly polluting industries, the Brazilian government is considering weakening environmental licensing rules for infrastructure, agricultural and industrial projects, with the objective of strengthening the economy (Fearnside, 2016; Fernandes et al., 2016; Tollefson, 2016). This decision would end environmental assessments, facilitating and speeding up large development projects such as ports and mining. The joint effects of corruption and political instability on policy making are bringing irreversible environmental damage to Brazil and undermining the possibilities of sustainable use of its natural resources.

Minimize impacts of ocean acidification

Over two trillion tons of CO_2 have already been emitted since the industrial revolution, and the next two trillion tons are expected to be released in the next three decades (Xu and Ramanathan, 2017). This increase in the concentration of carbon dioxide in Earth's atmosphere has driven an increase in the oceans' temperature, sea level, and has depleted seawater carbonate concentrations, resulting in ocean acidification (Hoegh-Guldberg et al., 2007). Ocean acidification has the potential to bring the loss of structural integrity in coralline ecosystems (Ragazzola et al., 2012), increase community-scale calcification sensitivity in coral reefs (Albright et al., 2018), and also affect the behavior and ecology of fishes (Cripps et al., 2011). Elevated temperatures are driving the collapse of coral reefs, the most biodiverse ecosystems in tropical regions (Hughes et al., 2017b) and the extinction, invasion and turnover of marine species in high latitudes (Cheung et al., 2009). Ocean warming and acidification will severely affect fishing activities and tourism, unchaining large socio-economic impacts in activities of promising sustainable development.

The Paris Agreement on climate change (COP 21) aims to control the increase in global average temperatures, and the target SDG 14.3 focuses on minimizing the impacts of ocean acidification. However, one of the most polluting countries in the world, the USA, refuse to sign the agreement, maintaining a large usage of fossil fuels (natural gas, petroleum and coal) as main source of energy and development. Moreover, many developing signatory nations are still dependent on destructive and polluting practices to maintain or accelerate their development. The expansion of biofuel, often considered as an sustainable activity, is promoting destructive activities such as the replacement of highly biodiverse ecosystems by sugar cane plantations (Regis et al., 2017; Tollefson, 2018) and mining of rhodolith beds for producing sugar cane fertilizers, as well as correcting soil acidity (Vasconcelos, 2012). Hydroelectricity, also quoted as a "clean energy", usually produces large quantities of CO_2 and methane through the decomposition of organic matter from inside the reservoirs. In addition, there are severe negative impacts of dams to the integrity of river basin ecosystems and associated species (Scherer and Pfister, 2016).

Currently, most governance and management practices towards the ocean sustainability focus on local stressors. The progression to a multiscale governance able to deal with CO_2 emissions will depend on a worldwide shift in conservation paradigms. Adjustments for the conservation and sustainability of marine resources in our changing world include the redefinition of management goals, active manipulation of ecosystems, building institutions able to provide stronger governance, fostering innovative partnerships, changing social norms, among other adaptive approaches (Hughes et al., 2017a).

Hope for a sustainable future

Challenges for marine conservation and sustainability are enormous and the world needs to address them urgently. However, there is hope. For example, the amount of CBD signatory parties and the over 6000 commitments declared in the Ocean Conference are positive signs. Some countries, such as Palau (Box 2) and Costa Rica, show that sustainable development can be achieved alongside a high level of species and habitat protection. Brazil, China and the Philippines, developing countries under high anthropogenic pressure and that shelter high marine biodiversity and endemism, are committed to provide funding towards marine protection and management. China is also focused on trying to restore 5% of its coastal areas, and ensuring that the extension of natural shoreline does not fall below 35%. Traditional fishing territories and marine protected areas are benefiting small-scale fishers where they exist and are enforced. The participation of local fishers in resource management has brought excellent results for conservation in Brazil (TAMAR Project, Marcovaldi and Marcovaldi, 1999), Mexico (Cabo Pulmo National Park, Aburto-Oropeza et al., 2011), and many Pacific Islands (Cinner and Aswani, 2007; Dumas et al., 2010).

Oceanic MPAs, when appropriately placed (i.e. protecting high biodiversity habitats or spawning and feeding areas) and well enforced, show near-pristine conditions (Longo et al., 2015), providing important information that allow the assessment of human pressure elsewhere and the establishment of conservation goals (Knowlton and Jackson, 2008). The large and remote MPAs recently

created in Brazil offer strong opportunities for the establishment of management councils and to debate the need for the coverage of fragile ecosystems and species that are currently unprotected (Box 2). For instance, joint actions by managers, scientists and the military already led to the implementation of the first management rules restricting fisheries in zones of high importance for biodiversity and endemism situated outside the borders of such large MPAs. Furthermore, a few states, such as California (USA) and São Paulo (Brazil), in contrast to national polices, are promoting ample opportunities for sustainable development and coastal protection. California created the Marine Life Protection Act in 1999, which enabled the improvement of its system of protected areas, currently counting with over 120 MPAs, and representing almost 10% of state waters as no-take zones (Kirlin et al., 2013). Many developed countries have strict regulations against polluting industries, mining and port activities, and also set examples of waste treatment and usage as energy source, measures that should be followed by emergent countries.

Governments are recognizing the value of ecosystem services and natural infrastructure, launching insurance programs to protect natural habitats in order to decrease monetary investment and losses from coastal storms (McCreless and Beck, 2016). Developing countries such as China and India are committed to invest more in clean energy than any other nation, and the withdraw of the USA from the Paris Agreement did not discourage Americans, as 600 local officials representing 120 million people and over 900 companies (worth over U$ 6.2 trillion) reaffirmed their commitments (Kurz and Cicin-Sain, 2017). The Our Ocean Conference, held in Malta in October 2017, brought together the private sector and almost a thousand representatives of international institutions, and gathered 50 concrete commitments under the climate change theme, worth more than EUR 309 million (Kurz and Cicin-Sain, 2017). Action-oriented reports and many initiatives to combat climate change through ocean conservation were recently outlined in the COP23 (Picourt et al., 2017).

Thus, we need to map and recognize the problems, but hope and optimism must be the main trigger for science-based actions towards the SDG 14 and beyond (Visbeck, 2018). Environmental managers, scientists, and fishers of CBD signatory countries must work together and strategically to multiply the inspiring examples of hope for marine ecosystems that are priorities for conservation, but are still threatened. A large proportion of the human population lives near the ocean, and substantial investment in education and outreach is necessary to engage citizens to defend their quality of life, ecosystem services, and resources they depend on. Finally, a broad participation of different sectors of the human society is vital for the success of measures proposed towards the sustainability of the world's marine biodiversity.

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References

Aburto-Oropeza, O., Erisman, B., Galland, G.R., Mascareñas-Osorio, I., Sala, E., Ezcurra, E., 2011. Large recovery of fish biomass in a no-take marine reserve. PLoS ONE 6, http://dx.doi.org/10.1371/journal.pone.0023601.

Albright, R., Takeshita, Y., Koweek, D.A., Ninokawa, A., Wolfe, K., Rivlin, T., Nebuchina, Y., Young, J., Caldeira, K., 2018. Carbon dioxide addition to coral reef waters suppresses net community calcification. Nature 555, 516–519, http://dx.doi.org/10.1038/nature25968.

Barnes, M.D., Glew, L., Wyborn, C., Craigie, I.D., 2018. Prevent perverse outcomes from global protected area policy. Nat. Ecol. Evol., http://dx.doi.org/10.1038/s41559-018-0501-y.

Bianchini, A., 2016. Avaliação do impacto da lama/pluma Samarco sobre os ambientes costeiros e marinhos (ES e BA) com ênfase nas Unidades de Conservação.

Buruaem, L.M., Hortellani, M.A., Sarkis, J.E., Costa-lotufo, L.V., Abessa, D.M.S., 2012. Contamination of port zone sediments by metals from Large Marine Ecosystems of Brazil. Mar. Pollut. Bull. 64, 479–488, http://dx.doi.org/10.1016/j.marpolbul.2012.01.017.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R., Pauly, D., 2009. Projecting global marine biodiversity impacts under climate change scenarios. Fish Fish. 10, 235–251, http://dx.doi.org/10.1111/j.1467-2979.2008.00315.x.

Cinner, J.E., Aswani, S., 2007. Integrating customary management into marine conservation. Biol. Conserv. 140, 201–216, http://dx.doi.org/10.1016/j.biocon.2007.08.008.

Cripps, I.L., Munday, P.L., McCormick, M.I., 2011. Ocean acidification affects prey detection by a predatory reef fish. PLoS ONE 6, e22736, http://dx.doi.org/10.1371/journal.pone.0022736.

Day, J.C., Laffoley, D., Zischka, K., 2015. Marine Protected Area Management. In: Worboys, G.L., Lockwood, M., Kothari, A., Feary, S., Pulsford, I. (Eds.), Protected Area Governance and Management. ANU Press, Canberra, pp. 609–650.

Devillers, R., Pressey, R.L., Grech, A., Kittinger, J.N., Edgar, G.J., Ward, T., Watson, R., 2015. Reinventing residual reserves in the sea: are we favouring ease of establishment over need for protection? Aquat. Conserv. Mar. Freshw. Ecosyst. 25, 480–504, http://dx.doi.org/10.1002/aqc.2445.

Diaz, R.J., Rosenberg, R., 2008. Spreading dead zones and consequences for marine ecosystems. Science 321, 926–929, http://dx.doi.org/10.1126/science.1156401.

Doumbouya, A., Camara, O.T., Mamie, J., Intchama, J.F., Jarra, A., Ceesay, S., Guèye, A., Ndiaye, D., Beibou, E., Padilla, A., Belhabib, D., 2017. Assessing the effectiveness of monitoring control and surveillance of illegal fishing: the case of West Africa. Front. Mar. Sci. 4, 50, http://dx.doi.org/10.3389/fmars.2017.00050.

Driscoll, D.A., Bland, L.M., Bryan, B.A., Newsome, T.M., Nicholson, E., Ritchie, E.G., Doherty, T.S., 2018. A biodiversity-crisis hierarchy to evaluate and refine conservation indicators. Nat. Ecol. Evol., http://dx.doi.org/10.1038/s41559-018-0504-8.

Dumas, P., Jimenez, H., Léopold, M., Petro, G., Jimmy, R., 2010. Effectiveness of village-based marine reserves on reef invertebrates in Emau, Vanuatu. Environ. Conserv. 37, 364–372, http://dx.doi.org/10.1017/S0376892910000536.

FAO, 2002. Information on Fisheries Management in Micronesia [WWW Document], http://www.fao.org/fi/oldsite/FCP/en/FSM/body.htm (accessed 02.08.17).

Fearnside, P.M., 2016. Brazilian politics threaten environmental policies. Science (80-.) 353, 746–748, http://dx.doi.org/10.1126/science.aag0254.

Fernandes, G.W., Goulart, F.F., Ranieri, B.D., Coelho, M.S., Dales, K., Boesche, N., Bustamante, M., Carvalho, F.A., Carvalho, D.C., Dirzo, R., Fernandes, S., Galetti, P.M., Millan, V.E.G., Mielke, C., Ramirez, J.L., Neves, A., Rogass, C., Ribeiro, S.P., Scariot, A., Soares-Filho, B., 2016. Deep into the mud: ecological and socio-economic impacts of the dam breach in Mariana, Brazil. Nat. Conserv. 4, 35–45, http://dx.doi.org/10.1016/j.ncon.2016.10.003.

Giglio, V.J., Pinheiro, H.T., Bender, M.G., Bonaldo, R.M., Costa-lotufo, L.V., Ferreira, C.E.L., Floeter, S.R., Freire, A., Gasparini, J.L., Joyeux, J., Paulo, J., Lindner, A., Longo, G.O., Lotufo, T.M.C., Loyola, R., Luiz, O.J., Macieira, R.M., Magris, R.A., Mello, T.J., Quimbayo, J.P., Rocha, L.A., Segal, B., Teixeira, J.B., Vila-nova, D.A., Vilar, C.C., Zilberberg, C., Francini-Filho, R., 2018. Large and remote marine protected areas in the South Atlantic Ocean are flawed and raise concerns: comments on Soares and Lucas (2018). Mar. Policy 96, 13–17, http://dx.doi.org/10.1016/j.marpol.2018.07.017.

Greenpeace, 2015. Africa's Fisheries' Paradise at a Crossroads.

Hilborn, R., 2016. Marine biodiversity needs more than protection. Nature 535, 224–226, http://dx.doi.org/10.1038/535224a.

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K., Knowlton, N., Eakin, C.M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A., Hatziolos, M.E., 2007. Coral reefs under rapid climate change and ocean acidification. Science 318, 1737–1742, http://dx.doi.org/10.1126/science.1152509.

Hughes, T.P., Barnes, M.L., Bellwood, D.R., Cinner, J.E., Cumming, G.S., Jackson, J.B.C., Kleypas, J., Leemput, I.A., van de Lough, J.M., Morrison, T.H., Palumbi, S.R., Nes, E.H., Van Scheffer, M., 2017a. Coral reefs in the Anthropocene. Nature 546, 82–90, http://dx.doi.org/10.1038/nature22901.

Hughes, T.P., Kerry, J., Álvarez-Noriega, M., Álvarez-Romero, J., Anderson, K., Baird, A., Babcock, R., Beger, M., Bellwood, D., Berkelmans, R., Bridge, T., Butler, I., Byrne, M., Cantin, N., Comeau, S., Connolly, S., Cumming, G., Dalton, S., Diaz-Pulido, G., Eakin, C.M., Figueira, W., Gilmour, J., Harrison, H., Heron, S., Hoey, A.S., Hobbs, J.-P., Hoogenboom, M., Kennedy, E., Kuo, C.-Y., Lough, J., Lowe, R., Liu, G., Malcolm McCulloch, H.M., McWilliam, M., Pandolfi, J., Pears, R., Pratchett, M., Schoepf, V., Simpson, T., Skirving, W., Sommer, B., Torda, G., Wachenfeld, D., Willis, B., Wilson, S., 2017b. Global warming and recurrent mass bleaching of corals. Nature, http://dx.doi.org/10.1038/nature21707.

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Lavender, K., 2015. Plastic waste inputs from land into the ocean. Science 347, 768–770, http://dx.doi.org/10.1017/CBO9781107415386.010.

Jones, P.J.S., De Santo, E.M., 2016. Is the race for remote, very large marine protected areas (VLMPAs) taking us down the wrong track? Mar. Policy 73, 231–234.
Kirlin, J., Caldwell, M., Gleason, M., Weber, M., Ugoretz, J., Fox, E., Miller-Henson, M., 2013. California's Marine Life Protection Act Initiative: supporting implementation of legislation establishing a statewide network of marine protected areas. Ocean Coast. Manag. 74, 3–13, http://dx.doi.org/10.1016/j.ocecoaman.2012.08.015.
Knowlton, N., Jackson, J.B.C., 2008. Shifting baselines, local impacts, and global change on coral reefs. PLoS Biol. 6, e54, http://dx.doi.org/10.1371/journal.pbio.0060054.
Kroodsma, D.A., Mayorga, J., Hochberg, T., Miller, N.A., Boerder, K., Ferretti, F., Wilson, A., Bergman, B., White, T.D., Block, B.A., Woods, P., Sullivan, B., Costello, C., Worm, B., 2018. Tracking the global footprint of Fisheries. Science 359, 904–908, http://dx.doi.org/10.1126/science.aao5646.
Kurz, M., Cicin-Sain, B., 2017. Assessing Progress on Ocean and Climate Action: 2016–2017. A Report of the Roadmap to Oceans and Climate Action (ROCA) Initiative.
Lindegren, M., Holt, B.G., MacKenzie, B.R., Rahbek, C., 2018. A global mismatch in the protection of marine biodiversity and ecosystem services. Sci. Rep. 8, 4099, http://dx.doi.org/10.1038/s41598-018-22419-1.
Longo, G.O., Morais, R.A., Martins, C.D.L., Mendes, T.C., Aued, A.W., Cândido, D.V., de Oliveira, J.C., Nunes, L.T., Fontoura, L., Sissini, M.N., Teschima, M.M., Silva, M.B., Ramlov, F., Gouvea, L.P., Ferreira, C.E.L., Segal, B., Horta, P.A., Floeter, S.R., 2015. Between-habitat variation of benthic cover, reef fish assemblage and feeding pressure on the benthos at the only Atoll in South Atlantic: Rocas Atoll, NE Brazil. PLOS ONE 10, e0127176, http://dx.doi.org/10.1371/journal.pone.0127176.
Marcovaldi, A., Marcovaldi, G.G., 1999. Marine turtles of Brazil: the history and structure of Projeto TAMAR-IBAMA. Biol. Conserv. 91, 35–41.
McCreless, E., Beck, M.W., 2016. Rethinking our global coastal investment portfolio. J. Ocean Coast. Econ. 3, 21, http://dx.doi.org/10.15351/2373-8456.1069.
Nations, U., 2018. Brazil Designates Two New Marine Protected Areas, Surpassing Biodiversity Targets [WWW Document], https://www.unenvironment.org/news-and-stories/press-release/brazil-designates-two-new-marine-protected-areas-surpassing.
O'Leary, B.C., Ban, N.C., Fernandez, M., Friedlander, A.M., García-borboroglu, P., Golbuu, Y., Guidetti, P., Harris, J.M., Julie, P., Langlois, T.I.M., Douglas, J., Pikitch, E.K., Richmond, R.H., Roberts, C.M., 2018. Addressing criticisms of large-scale marine protected areas. Bioscience 68, 359–370, http://dx.doi.org/10.1093/biosci/biy021.
Ocean Conservancy, 2015. Stemming the Tide: Land-based Strategies for a Plastic-free Ocean.
Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., Torres, F., 1998. Fishing down marine food webs. Science 279, 860–863, http://dx.doi.org/10.1126/science.279.5352.860.
Picourt, L., Courcy, C., Brun, V., 2017. Measuring Progress on Ocean and Climate Initiatives: An Action-Oriented Report.
Pinheiro, H.T., Di Dario, F., Gerhardinger, L.C., Melo, M.R.S., de Moura, R.L., Reis, R.E., Vieira, F., Zuanon, J., Rocha, L.A., 2015. Brazilian aquatic biodiversity in peril. Science 350, 1043–1044, http://dx.doi.org/10.1126/science.350.6264.1043-a.
Pınarbaşı, K., Galparsoro, I., Borja, Á., Stelzenmüller, V., Ehler, C.N., Gimpel, A., 2017. Decision support tools in marine spatial planning: present applications, gaps and future perspectives. Mar. Policy 83, 83–91, http://dx.doi.org/10.1016/j.marpol.2017.05.031.
Ragazzola, F., Foster, L.C., Form, A., Anderson, P.S.L., Hansteen, T.H., Fietzke, J., 2012. Ocean acidification weakens the structural integrity of coralline algae. Glob. Chang. Biol. 18, 2804–2812, http://dx.doi.org/10.1111/j.1365-2486.2012.02756.x.
Reese, A., 2017. Australian government to roll back marine protections. Science 357, http://dx.doi.org/10.1126/science.aan7145.
Regis, M., Verde, L., Duft, D.G., Hernandes, T.A.D., Bordonal, R.D.O., 2017. Brazilian sugarcane expansion and deforestation. In: 25th European Biomass Conference and Exhibition, pp. 1476–1483, http://dx.doi.org/10.5071/25thEUBCE2017-4CO.2.4.
Roberts, K.E., Valkan, R.S., Cook, C.N., 2018. Measuring progress in marine protection: a new set of metrics to evaluate the strength of marine protected area networks. Biol. Conserv. 219, 20–27, http://dx.doi.org/10.1016/j.biocon.2018.01.004.
Rocha, L.A., 2018. Bigger Is Not Better for Ocean Conservation. New York Times op-ed Contributor.
Sala, E., Lubchenco, J., Grorud-Colvert, K., Novelli, C., Roberts, C., Sumaila, U.R., 2018. Assessing real progress towards effective ocean protection. Mar. Policy 91, 11–13, http://dx.doi.org/10.1016/j.marpol.2018.02.004.
Scherer, L., Pfister, S., 2016. Hydropower's biogenic carbon footprint. PLOS ONE 11, e0161947, http://dx.doi.org/10.1371/journal.pone.0161947.
Tickler, D., Meeuwig, J.J., Palomares, M., Pauly, D., Zeller, D., 2018. Far from home: distance patterns of global fishing fleets. Sci. Adv. 4, eaar3279, http://dx.doi.org/10.1126/sciadv.aar3279.
Tollefson, J., 2018. Brazil's lawmakers push to weaken environmental rules. Nature 557, 17.
Tollefson, J., 2016. Brazil debates loosening environmental protections. Nature 539, 147–148, http://dx.doi.org/10.1038/509015a.
Vasconcelos, Y., 2012. Fertilizante marinho. Uso de algas calcárias como adubo em lavouras de cana pode elevar a produtividade em até 50%. Pesqui. Fapesp Julho, 62–64.
Visbeck, M., 2018. Ocean science research is key for a sustainable future. Nat. Commun. 9, 1–4, http://dx.doi.org/10.1038/s41467-018-03158-3.
Wilson, P., 2007. A tuna industry in Micronesia? Micronesian Couns., 2–18.
Worm, B., Lotze, H.K., Jubinville, I., Wilcox, C., Jambeck, J., 2017. Plastic as a Persistent Marine Pollutant. Annu. Rev. Environ. Resour. 42, 1–26, http://dx.doi.org/10.1146/annurev-environ-102016-060700.
Xu, Y., Ramanathan, V., 2017. Well below 2 °C: Mitigation strategies for avoiding dangerous to catastrophic climate changes. Proc. Natl. Acad. Sci. 114, 10315–10323, http://dx.doi.org/10.1073/pnas.1618481114.
Zhang, K., Dearing, J.A., Tong, S.L., Hughes, T.P., 2016. China's degraded environment enters a new normal. Trends Ecol. Evol. 31, 175–177, http://dx.doi.org/10.1016/j.tree.2015.12.002.