A Rationale for Strong Protection of Montserrat's Marine Environment

Waitt Institute

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Executive Summary

I. **Montserrat has committed to protecting 10-30% of its waters as no-take marine reserves in line with international targets.**
   - The Government of Montserrat established a voluntary commitment during the UN Ocean Conference to protect 10-30% as no-take zones.
   - This commitment built on the 2015 Memorandum of Understanding between the Government of Montserrat and the Waitt Institute to develop and codify sanctuary zones that prohibit fishing.
   - The Convention on Biological Diversity, to which the United Kingdom is a party, calls for the protection of at least 10% of the marine environment by 2020.
   - The International Union for Conservation of Nature (IUCN) to which the United Kingdom is a party through Defra calls upon nations to protect at least 30% of the ocean from extractive activities.

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II. **Without strong leadership, Montserrat's conservation efforts will fall short of national and international targets.**
   - In 2015, the Government of Montserrat launched the Blue Halo Initiative with the goal of managing Montserrat's waters for sustainability, profitability, and enjoyment, resulting in healthier ecosystems, improved fishing catches, and strengthened coastal livelihoods.
   - The Blue Halo Steering Committee, an advisory body, recently developed three draft Marine Spatial Plan (MSP) options, which are now under consideration by MATHLE. Only one of these options meets the target of 10% no-take marine protection.
   - The current marine spatial planning effort is the fourth time that Montserrat has considered creating ocean management areas since 1986. All previous efforts have failed to adopt and implement a final plan.

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III. **Montserrat's marine environment has experienced substantial natural and anthropogenic impacts, which require improved management for long-term sustainability.**
   - Montserrat's marine environment has been profoundly impacted by volcanic eruptions, fishing, local development and climate change. These natural and anthropogenic impacts have already contributed to the decline of Montserrat's fish stocks, coral reefs, and mangroves.
   - The Montserrat Fisheries Assessment (2016) found that several of the top-landed species in Montserrat may be experiencing mild to moderate overfishing. Without effective management, fishing yield will decline.
   - Reef fish are primarily caught using fish traps. These traps are non-selective and can further contribute to declining fish stocks.
   - Additional impacts to the marine ecosystem related to climate change may further diminish ecosystem health and key ecosystem services.

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IV. **Designed and managed effectively, Montserrat's Marine Spatial Plan provides an opportunity to create fish nurseries, increase fish biomass, and protect corals and other endangered species.**
- Marine protected areas are the most effective tool to protect marine ecosystems and mitigate negative impacts.
- A large body of research has shown that protected areas can increase fish biomass, protect endangered species, help maintain biodiversity and improve overall ecosystem resilience. As marine protected areas mitigate the negative effects of fishing, they can act as an important complement to fisheries management regulations.
- Catch projection models from the Montserrat Fisheries Assessment indicate that fishery yield for silk snapper and red hind will increase through the creation of no-take protected areas.

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V. **No-take areas are the most effective marine protection tool to trigger a positive ecosystem response.**
- Numerous studies have shown that MPAs with no-take protections have greater conservation effects than MPAs with lower levels of protection.
- Partially protected areas are more challenging to enforce. Unless highly regulated, the effects of partially protected areas are indistinguishable from unregulated areas.

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VI. **Research shows that 30% of marine waters should be protected to achieve the best conservation and fisheries outcomes.**
- IUCN recommends protecting at least 30% of marine waters, a recommendation that builds upon research showing the ecological and socioeconomic benefits of protected areas and best practices for marine protected area design.
- Conservation benefits of marine protected areas include increases in the density, biomass, size and diversity of marine life inside the protected area.
- Conservation benefits spill over to fishing grounds outside of protected areas and can thus increase fisheries yield over time.

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VII. **Marine Protected Areas and Marine Spatial Planning support economic well-being**
- No-take marine protected areas will increase fishery yields, meaning there is more fish to eat and sell in the long term.
- Beyond no-take reserves, ocean zoning can encourage economic development and reduce conflict in highly used areas.

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I. Montserrat has committed to protecting 10-30% of its waters as fully protected marine reserves in line with international targets.

Recognizing the need for strong marine protection and global goals to achieve such targets, the Government of Montserrat committed to 10-30% "no-take" protection by 2020. During the UN Ocean Conference in June 2017, the Government of Montserrat made a voluntary commitment to protect 10-30% of the island's marine environment as no-take marine reserves. Voluntary commitments are initiatives undertaken by Governments and partners to advance the implementation of Sustainable Development Goal (SDG) 14 and associated targets, reflecting critical linkages between SDG 14 and other Sustainable Development Goals. Montserrat registered its commitment in support of SDG targets 14.2, 14.4, and 14.5 (https://oceanconference.un.org/commitments/?id=18142). Montserrat's commitment built on the 2015 Memorandum of Understanding between the Government of Montserrat and Waitt Institute, through which the parties agreed to develop and codify the Montserrat Sustainable Ocean Policy, including sanctuary zones that prohibit fishing.

Montserrat's UN commitment aligns with other international targets that call for 10 to 30% protection of national waters. In 2010, under the Convention on Biological Diversity (CBD) Aichi Targets to which the UK is a party, nations declared the need to protect at least 10% of the marine environment by 2020 (Aichi Target 11). In 2014, the UN Conference on Small Island Developing States created the SIDS Accelerated Modalities of Action (SAMOA) Pathway, which also declared the target of 10% marine protection by 2020. In 2015, nations adopted the Sustainable Development Goals (SDGs) under the United Nations, including SDG 14, which yet again calls for conservation of at least 10% of coastal and marine areas by 2020 (UN, SDGs). With 16 months until 2020, the world is woefully behind schedule with less than 4% of the world's ocean under strong marine protection (MPAtlas).

The International Union for Conservation of Nature (IUCN), to which the UK is a member through DEFRA, recommended a target of 30% no-take Marine Protected Area (MPA) coverage worldwide during the 2014 World Parks Congress (2014), calling upon nations to "[urgently increase the ocean area that is effectively and equitably managed in ecologically representative and well-connected systems of MPAs or other effective conservation measures]". This network should target protection of both biodiversity and ecosystem services and should include at least 30% of each marine habitat. This recommendation was reinforced by a resolution passed at the IUCN World Conservation Congress in Hawai'i 2016, calling for nations to "….designate and implement at least 30% of each marine habitat in a network of highly protected MPAs and other effective area-based conservation measures, with the ultimate aim of creating a fully sustainable ocean, at least 30% of which has no extractive activities, subject to the rights of indigenous peoples and local communities" (Resolution WCC-2016-Res-050).

The marine spatial planning process provides the opportunity for Montserratians to be stewards of their environment and achieve environmental national and international targets.

II. Without strong leadership, Montserrat's conservation efforts will fall short of national and international targets

For over 30 years, Montserrat has recognized the need and utility of protecting its marine resources and has explored marine spatial planning options. In 2015, the Government of Montserrat launched the Blue Halo Initiative to achieve the sustainable, profitable, and enjoyable use of ocean resources through marine spatial planning, ocean zoning, sanctuary areas and fisheries management. This multi-year effort included an 18-months long participatory process that has culminated in the development of three draft marine spatial plans, which are now under consideration by the Ministry of Agriculture, Trade, Housing, Lands, and Environment (MATHLE). Only one draft plan meets Montserrat's target of 10% no-take marine protection.

The current marine spatial planning effort is the fourth time that Montserrat has considered creating a network of ocean management areas since 1986. All previous efforts have failed to adopt and implement a final plan.

Past efforts to protect Montserrat's waters

In the mid-1980s, the Montserrat National Trust began a campaign which included a thorough scoping of information available on the terrestrial and marine environment (Figure 1A, Bovey et al. 1986). In this effort, a large area that extended around the northern portion of the island and bounded by Little Bay and Margarita Bay was proposed as a Marine Park. In 1993, the same proposal was included in another study conducted by the Island Resources Foundation. A new proposal was developed in 1996 in association with the Montserrat National Trust through a study aimed at characterizing the biodiversity of coral reefs of Montserrat with the intent to use the information to inform the designation of marine protected areas (Figure 1B, Brosnan et al. 1996).

After the eruptions of the Soufriere Hills stabilized, the Government of Montserrat re-focused on the need to manage the marine environment. At this time, marine resources had suffered major impacts from the volcano, and large infrastructure projects were occurring that would impact the marine environment as well. Researchers conducted a feasibility study to explore the possibility of establishing marine protected areas and to design a stakeholder management process for governing the nearshore waters of Montserrat (Figure 1C, Wild et al. 2007). These plans were the first to include a significant consultation process and incorporated pre- and post-eruption baseline studies of the marine environment. A draft marine spatial plan was proposed but never adopted.

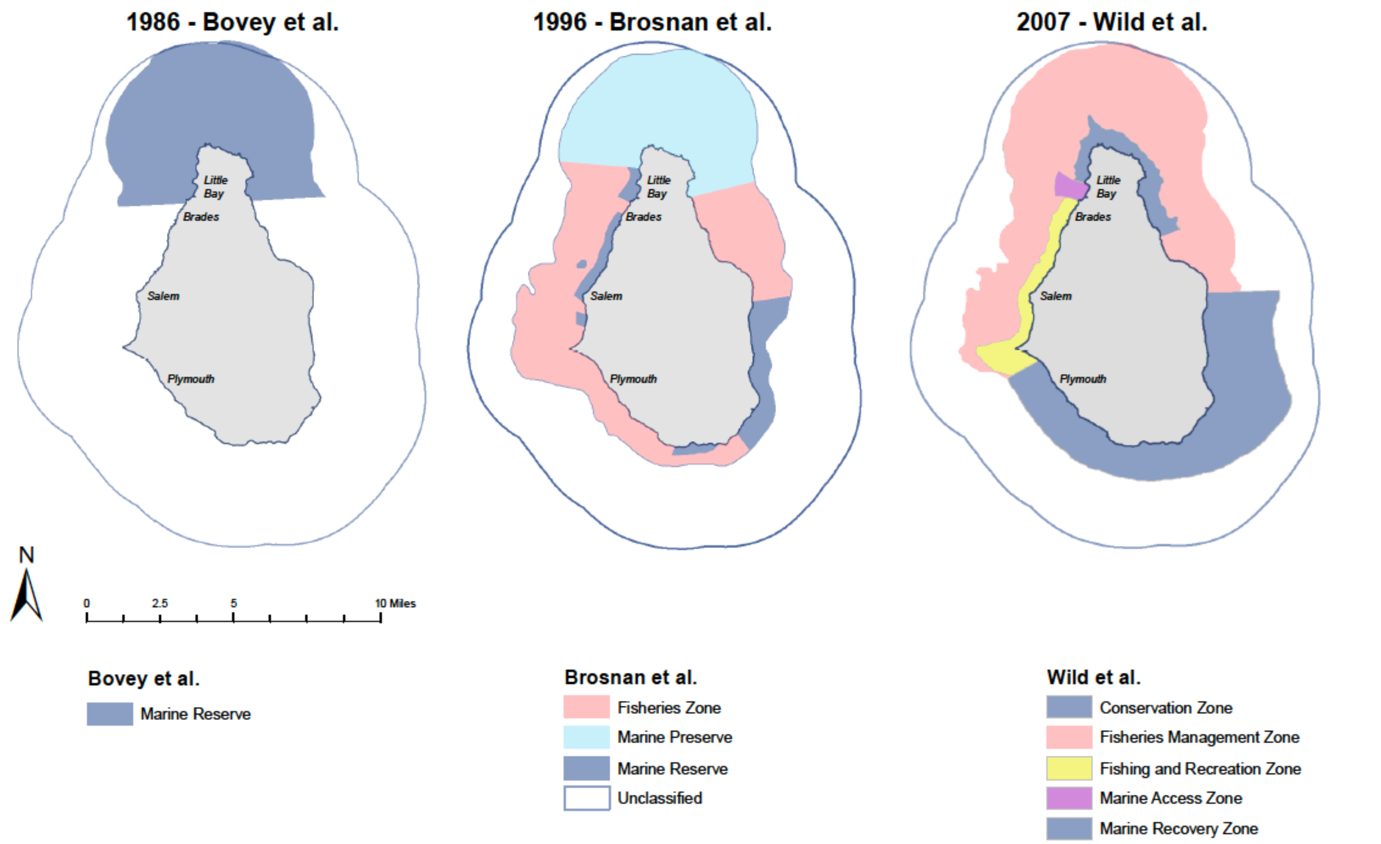


Figure 1. Past proposals to protect Montserrat's marine environment. 1A) Bovery et al, 1B) Brosnan et al, 1C) Wild et al

Current Proposals for Montserrat's Waters from the Blue Halo Consultation Process

In 2014, the Government of Montserrat contacted the Waitt Institute seeking support to partner in developing a science-based, stakeholder-driven marine spatial plan and to work together to adopt, implement, and sustainably finance this plan and associated regulations.

After a period of data collection, Montserrat launched its marine spatial planning process with the support of the Blue Halo Steering Committee, a government-appointed advisory body with members of Government and key stakeholders. Through an 18-months long participatory process, the Steering Committee worked with scientists, planners, and technical experts to draft multiple options for marine spatial plans. In each stage of development, the public and key stakeholders were invited to provide input. In June 2018, the Steering Committee evaluated 3 marine spatial plan options (Figure 2), which are now with MATHLE for consideration.

All options establish three categories of management areas in addition to existing exclusion zones. These include multi-use zones that are open to all current and future uses, protected areas that limit or prohibit fishing, and small utility areas for shipping, anchoring and recreation. The three options vary in the extent of marine protection, only one otion (Blue Halo Option C) reaches the 10% no-take target in line with Montserrat's UN commitment.

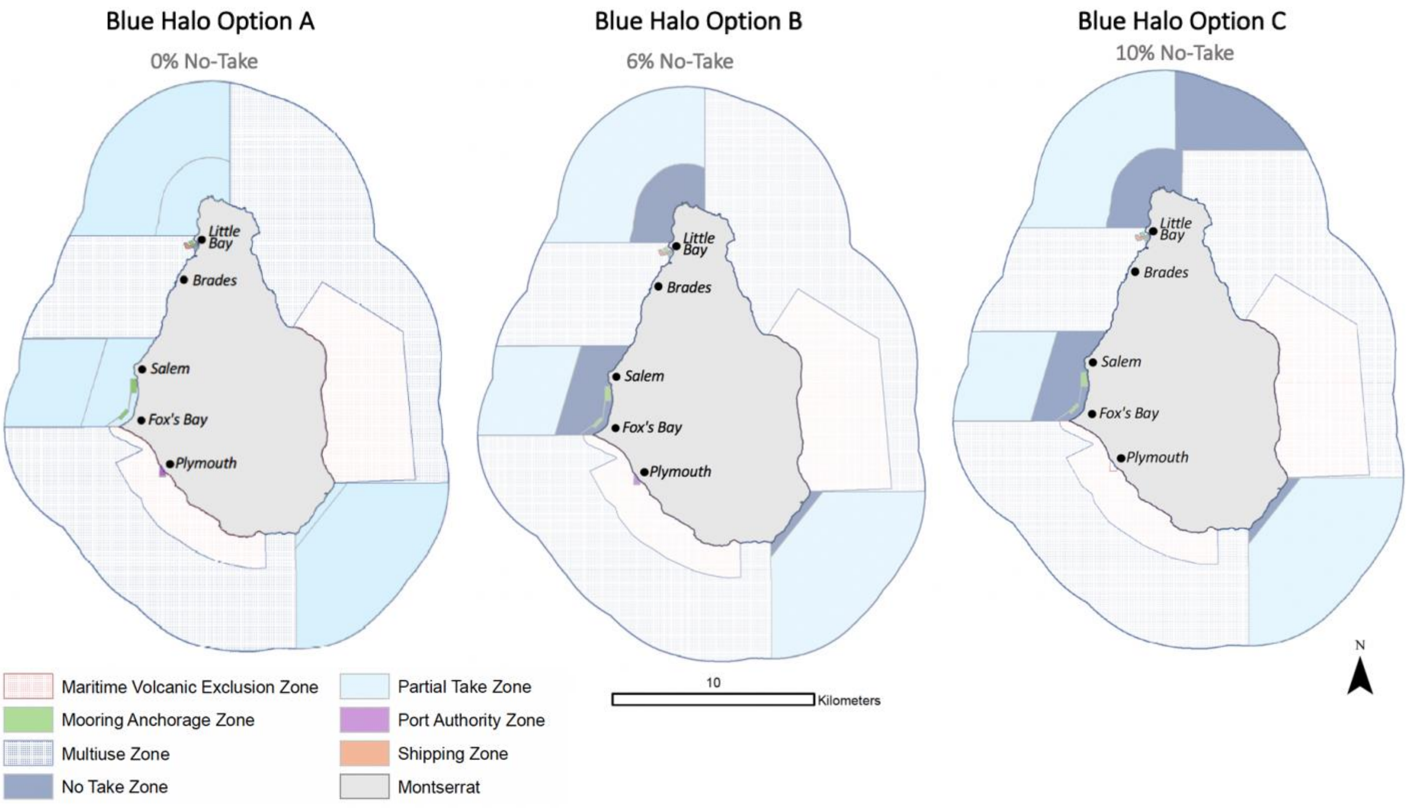
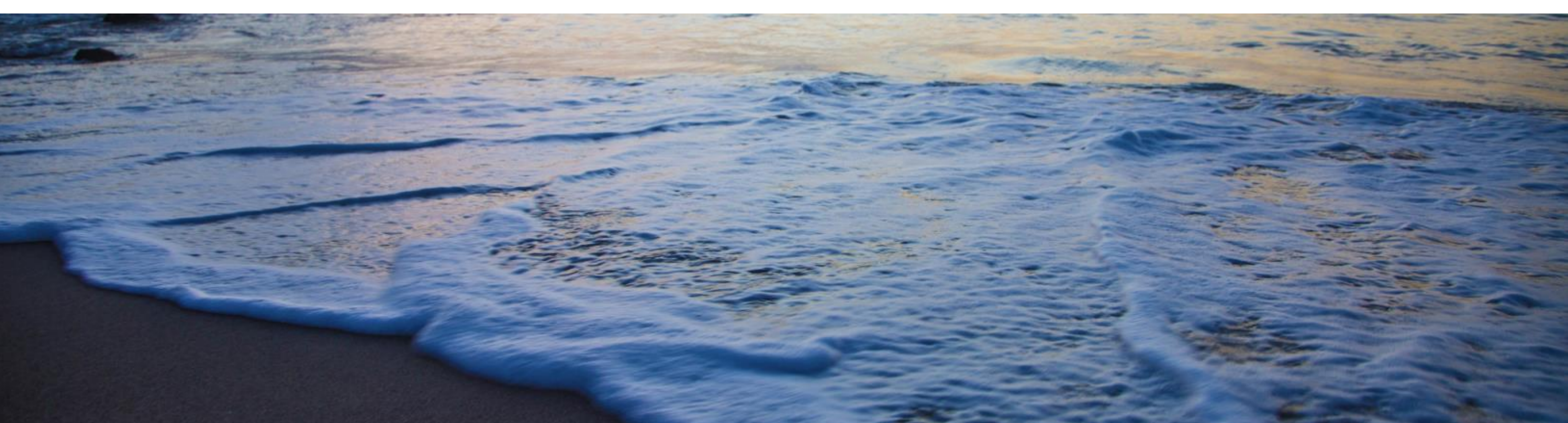


Figure 2. MSP Options From Blue Halo Steering Committee (2018)

Of these three plan options, the Waitt Institute recommends Blue Halo Option C as the best choice. The Committee chose this arrangement of three nested no-take and partial take zones for its ability to allow for more protection of the nearshore reef habitats while minimizing impact to fishers who participate in nearshore trolling. It maintains high-level protection of key biodiversity areas, protecting 35% of Montserrat's coral reefs in no-take and partial take zones and covering two-thirds of habitat identified as important to protect species richness. This plan achieves the 10% no-take goal for the nearshore environment in fulfillment of Montserrat's voluntary UN Commitment. In the most recent Blue Halo Steering Committee meeting, this plan received support from the Montserrat National Trust, Scuba Montserrat, and the Department of Physical Planning and Customs.



III. Montserrat’s marine environment has experienced substantial natural and anthropogenic impacts, which require improved management for long-term sustainability.

Montserrat’s marine environment has been profoundly impacted by volcanic eruptions, fishing, local development, and climate change. These natural and anthropogenic impacts have already contributed to the decline of Montserrat’s fish stocks, coral reefs, and mangroves. It is clear that coastal habitats are and will continue to be exposed to a series of human and/or natural threats that are expected to intensify in the future. Improved management practices that include no-take protected areas are critical to mitigate negative impacts, protect limited existing resources, and improve ecosystem recovery and resilience.

Overfishing causes declining catch, reducing fisher livelihoods over time. The Montserrat Fisheries Assessment (2016) found that most doctorfish, red hind and silk snapper are caught before maturity (before they can reproduce). Overfishing of blue tang and doctorfish is likely occurring, and overfishing of gar and silk snapper may also be occurring (**Figure 3**). Although the number of fishers is small, non-selective fishing methods can have a major impact on fish populations (Campbell et al., 2017).

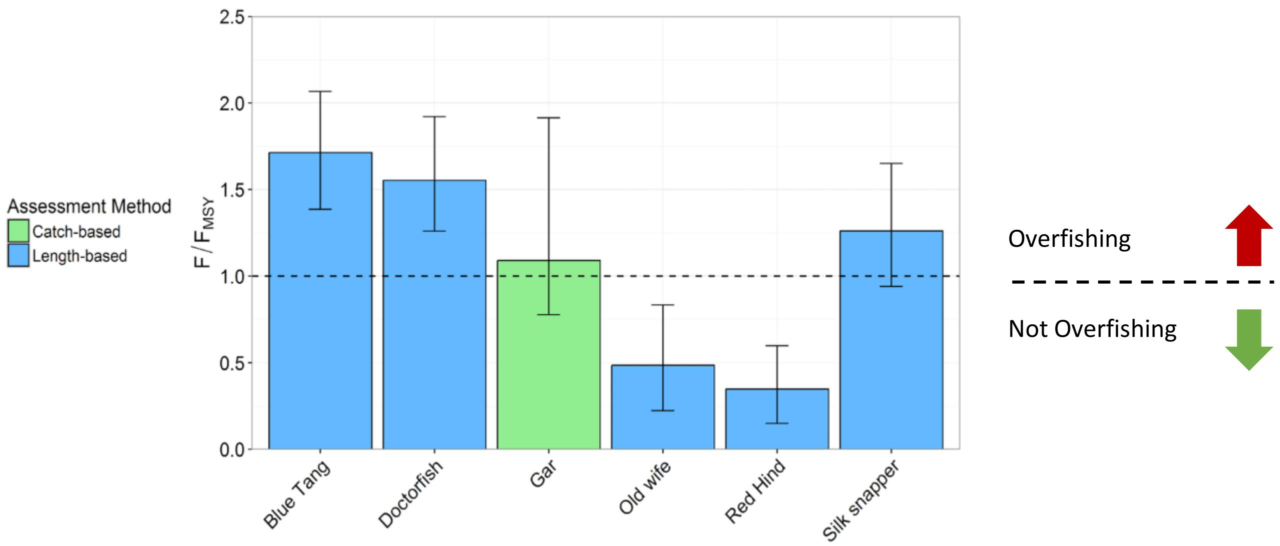


Figure 3. Status of Overfishing in Montserrat

The Montserrat Fisheries Assessment (2016) also found that fish traps are the most common fishing gear used, accounting for 47% of all fisheries landings since 1994. For fisheries managers, traps present a considerable challenge as they can impact fish stocks and ecosystems in a number of different ways. First, the small mesh sizes that are frequently used in traps result in the capture of juvenile fishes that have not yet reproduced (Mahon and Hunte, 2001). Second, traps have poor selectivity – they will retain any fish that enters the trap and is not able to find its way back out of the entrance funnel or escape through the mesh (Munro 1983). This indiscriminate harvest results in high catch diversity and the capture of many species that are not of commercial interest (Johnson, 2010). Third, fish traps catch herbivorous fish, including parrotfish (Scaridae) and surgeonfish (Acanthuridae), which play a vital role in facilitating coral growth and recovery by controlling the abundance of macroalgae on reefs (Mumby et al., 2006; Mumby and Harborne, 2010). Fourth, traps themselves can cause direct physical damage to habitats, such as scarring or breaking corals (Marshak et al., 2008). Finally, traps are frequently lost or abandoned. These traps will continue to catch fish for as long as their physical structure is intact (called "ghost fishing"), contributing to fish mortality rates (NOAA Marine Debris Program, 2015). Research found that no-take areas can mitigate these negative effects of fishing and can act as an important complement to fisheries management regulations (Gaines et al., 2010).

Soufriere Hills Volcano caused sedimentation on corals reducing reefs' carrying capacity. The volcanic eruptions from 1995 to 2010, and the large volumes of ash the volcano has deposited, likely had a significant impact on the marine environment. The ash was deposited in the coastal waters around Montserrat and can be seen on the coral reefs (Myers 2013). The presence of the ash smothers the reef, reducing the ability of corals and other organisms to grow and reproduce (Rogers 1990). It is likely that the impact of the volcano has reduced the carrying capacity (i.e., size of fish populations that can be supported) of the reef around Montserrat, especially in the south where the impacts of the volcano have been most severe (Myers 2013).

The unfortunate reality of this impact likely means that despite the decrease in the numbers of fishers since the volcano, there is now less habitat and therefore fewer fish for fishers to catch. It is imperative, therefore, for Montserrat to manage fisheries with a recognition of this loss.

Climate Change will exacerbate coral loss. Coral reefs are declining at unprecedented rates globally due to a combination of local and global stressors (Hoegh-Guldberg et al. 2007). One third of reef-building corals, which provide the habitat to thousands of species worldwide, are facing elevated extinction risk (Carpenter et al. 2008), and the majority of fished reefs are missing nearly half their expected biomass of reef fish, impacting ecosystem function (MacNeil et al. 2015). Climate change is already severely impacting reefs around the world, causing increased frequency and intensity of coral bleaching events (Hughes et al., 2017). By mid-century, Montserrat, along with most reefs in the Caribbean, is likely to experience annual bleaching events, leading to a loss of live coral cover and degradation of coral reef habitats (van Hooidonk et al. 2015). Tropical storm intensity is also increasing due to climate change (Elsner et al 2008, Knutson et al 2010), which will result in increased damage to ecosystems when hurricanes impact an area (Gardner et al., 2005). While MPAs cannot prevent impacts acting on global scales, it has been shown that properly-designed MPAs may improve resilience and therefore chances of recovery in the medium and long-term (Game et al. 2009).

While Montserrat, like all countries, must play a role in mitigating the causes of climate change, it must at the same time take actions towards adaptation that enhance ecosystem resilience and reduce vulnerability.

Local development threatens coastal ecosystems. Major threats to corals arise from local development and concomitant increases in run-off due to land use. Increasing coastal development in Caribbean islands and poor watershed management are often accompanied by destruction and removal of large mangrove areas and reductions in water quality. These impacts jeopardize the narrow set of physiological requirements that maximizes coral growth and their chances of survival (Hodgson 1999, Cooper et al.

2007, Carpenter et al. 2008). Most of these human disturbances are present in Montserrat. For example, a series of pollution problems (sewage and solid wastes) are currently noticed in Montserrat (Halcrow 2003; Wild et al. 2007). The expansion of the port at Little Bay will further impact the coastal ecosystems.

Montserrat lacks mangrove habitat, which is important for juvenile fishes. Due to a combination of volcanic and human activities, Montserrat has lost virtually all of its mangrove forest, which play a central role in sediment trapping and nutrient cycling (Twilley and Day 1999). These ecosystems also represent nursery areas for a variety keystone species and have been shown to increase biomass of reef fishes of commercial value (Nagelkerken et al. 2000, Mumby et al. 2004). The loss of mangroves as fish nurseries makes the establishment of no-take protected areas even more important for juvenile fish to grow and ultimately increase fish biomass.

Invasive Species cause substantial disturbance. For Montserrat's marine environment, key invasive species include the Indo-Pacific lionfish, *Pterois volitans* and *P. miles* as well as the seagrass, *Halophila stipulacea.* Lionfish outcompete other fish species for prey, and eat larvae of local species of ecological and commercial value.
Montserrat has also suffered a local extinction of native seagrass species. Anecdotal references suggest that the majority of native seagrasses were lost in the passing of Category 4 Hurricane Hugo and these habitats were not recolonized until after 2002 when H.stipulacea, an non-native seasgrass, arrived in the Caribbean. This species of seagrass has been shown to tolerate a significantly wider range of environmental conditions compared to native species thereby capable of settling in areas unsuitable for native grasses. Research is just beginning to see the long term consequences of wide scale phase shifts from native to invasive dominated seagrass habitats. Evidence is beginning to show that changes in dietary preference of macro grazers such as sea turtles, parrotfish, sting rays, and conch can show preference towards native grasses. Major changes have been documented in epibiotic, infaunal, and fish communties. Most notably, up to 50% reductions in fish populations and reductions in biodiversity (Becking et al. 2014). Given the opportunistic nature of H.stipulacea along with glimpses of long term effects, it is likely that native grasses in the Caribbean will continue to be overgrown and that the consequences will be significant on coral reef and seagrass ecology (Willette et al. 2012).

IV. Designed and managed effectively, Montserrat's Marine Spatial Plan provides an opportunity to create fish nurseries, increase fish biomass, and protect coral reef and other endangered species.

Marine protected areas are the most effective tool available for managers to protect marine ecosystems from anthropgenic impacts. Research has shown that protected areas increase fish biomass, protect endangered keystone species, help maintain biodiversity, and improve ecosystem resilience (Mumby et al. 2007, Hughes et al. 2007b, Davison and Dulby. 2017)

The Montserrat Fisheries Assessment modelled annual fishery yields and fish biomass for key species under management scenarios as well as business as usual. Catch projection modelling shows that 30% no-take MPA coverage will lead to a substantial increase in yields for silk snapper and red hind over a 30-year time period (Montserrat Fisheries Assessment 2016; Figure 4; Figure 5). Protecting 10% of Montserrat's waters as no-take shows a moderate increase in biomass and yield. Silk snapper and red hind are important components of the fisheries landings in Montserrat, and if no management measures are taken, fisheries yields are predicted to decline by at least 80% over the next 30 years (Figure 4, Figure 5- Business as usual scenario black line). The predicted increases in yields from protection seen for these two species would be expected for other reef species experiencing overfishing. Although it is likely there will be a decrease in catch in the first few years after MPAs are designated, over the long-term the MPAs are expected to produce net fisheries benefits.

Figure 4. Catch Projection Model for Red Hint

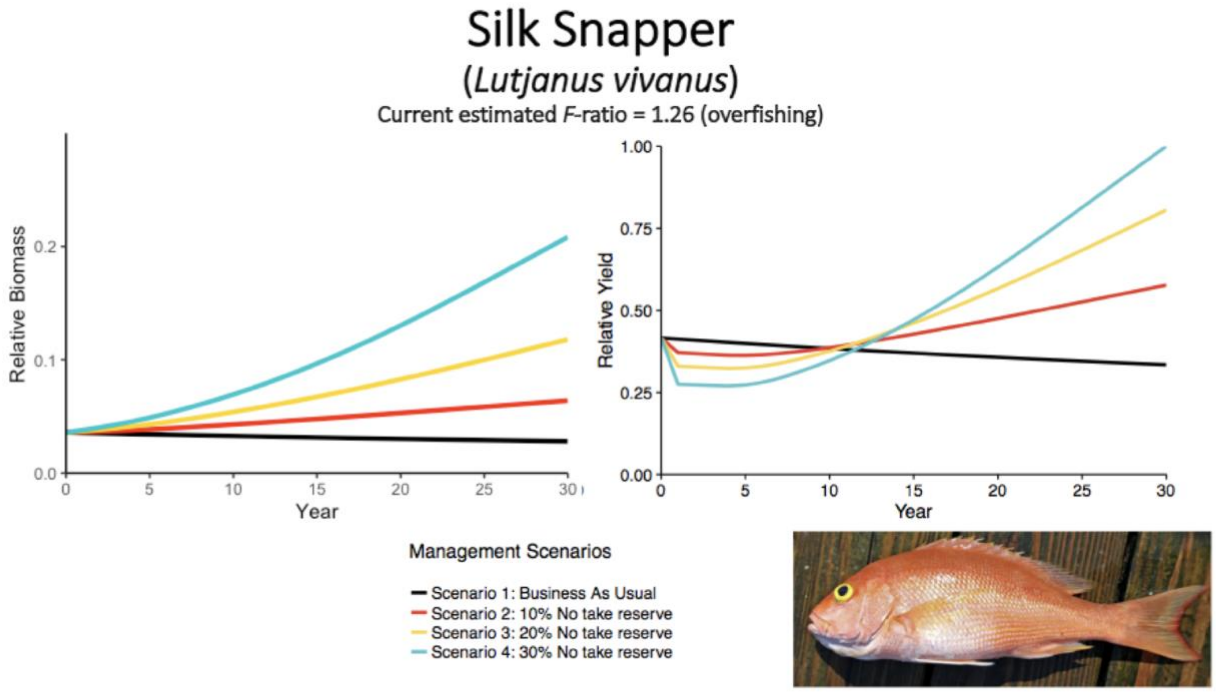


Figure 5. Catch Projection Model for Silk Snapper

V. No-take areas are the most effective marine protected area tool to achieve a positive ecosystem response

For maximum ecological benefits, managers should not allow extractive activities, such as fishing and mining, within MPAs. Numerous studies have shown greater conservation effects from no-take protection relative to lower levels of protection within MPAs (Lester and Halpern, 2008; Sciberras et al., 2013; Edgar et al., 2014; Giakoumi et al., 2017). However, in lieu of a total fishing ban, MPAs that allow some low impact fishing can still realize conservation benefits, and have been shown to have positive effects relative to no protection (Gill et al. 2017; Sciberras 2015).

In the absence of fully protected no-take reserves, what activities are permitted is pivotal to the conservation benefits of the protected area, as many partially protected areas have been found to be indistinguishable from those in unregulated areas. For example, a global study investigated protected areas effectiveness based on varying levels of restrictions. Sites that allowed fishing by multiple gear types (e.g., lines, nets, traps) had the same total fish biomass as sites that were open to all types of fishing. On the other hand, sites that allowed only hook and line fishing had higher biomass of many reef fish families relative to both the open sites and those that allowed fishing with multiple gear types (Campbell et al. 2017). Similarly, another global synthesis found higher abundance and biomass of commercially important species in highly regulated partially protected areas, but no conservation benefits of weakly regulated partially protected areas (Zupan et al., 2018).

Furthermore, MPAs can help mitigate the effects of climate change and increase the resilience of the encompassed species and habitats (McLeod et al., 2009; Roberts et al., 2017). For example, MPAs that protect key herbivore species tend to have lower macroalgal overgrowth of corals and higher densities of juvenile corals (Mumby et al., 2007; Mumby and Harborne, 2010), which increases their recovery potential after major disturbances (Steneck et al., 2018).

Importantly, MPAs can be thought of as an insurance policy: in the absence of strong management throughout an EEZ (including catch limits for fisheries, etc.), 30% or more protection will help ensure sustainability and preservation of key ecosystem services. However, it is crucial that established protected areas have adequate staff and financial resources in order for the above listed benefits to be realized (Gill et al., 2017).

VI. Research shows that 30% of marine waters should be protected to achieve the best conservation and fisheries outcomes.

IUCN's recommendations to protect at least 30% builds upon scientific evidence indicating that full protection of at least 30% of a region's waters benefits fisheries and conservation (Bohnsack et al., 2000; Gaines et al., 2010; O'Leary et al., 2016; Krueck et al., 2017). Conservation benefits include increases in the density, biomass, size and diversity of marine life inside MPA borders (Lester et al., 2009), and th protection of key habitat-forming species (e.g., corals and mangroves) that provide a foundation for health marine ecosystems. These conservation benefits of MPAs can also lead to fisheries benefits, particularly when fish stocks are overfished, by protecting nursery habitat for fished species and by providing recovery areas that supply larvae (i.e., export) and adults (i.e., spillover) to fished areas (Halpern, Lester and Kellner, 2009; Gaines et al., 2010). For example, in coral reef fisheries, strict protection of 20-30% of fished habitats was found to be unlikely to reduce catch, while helping to rebuild fish stocks and providing biodiversity conservation benefits (Krueck et al., 2017).

Beyond their benefits to fisheries and conservation, MPAs may provide tourism and recreation benefits. Tourists, especially scuba divers and snorkelers, are attracted to locations with large, abundant fish (Gill et al. 2015, Uyarra et al. 2005). In no-take MPAs there are generally more, larger fish, and of greater diversity than areas outside the MPAs (Lester et al. 2009). Therefore, successfully implemented MPAs could generate economic benefits to the tourism industry, and potentially be a source of revenue for conservation and MPA management if user fees are charged (Graham et al. 2011). MPAs have been shown to increase tourism value, as divers and other recreationists will pay more to visit pristine areas and will visit more often (Chae et al. 2012).

VII. Marine Protected Areas and Marine Spatial Planning support economic well-being

The overfished status of at least some of Montserrat's fishery species indicates that taking no management action will likely lead to decreasing fisheries yields, which could put future profits and livelihoods in jeopardy. In contrast, fish projection models show that effective protection will increase fisheries yield over time, meaning there is more fish to sell or eat locally. The biological impacts of taking management action are good for industry and for fish. MPAs have shown to increase tourism value, as divers and other recreationists will pay more to visit pristine areas, and marine-based tourism could increase (Chae et al. 2012). While the introduction of 10-30% no-take MPAs is expected to reduce fishers' yields in the short term, long term economic welfare is maximized when fisheries are managed so that harvests can be maintained annually at a maximum sustainable level. No-take MPAs are a tool that can be used to help rebuild fish stocks, providing a critical refuge for species which support ecosystem health and the local economy in the long term.

Looking beyond no-take reserves, the MSP process also involves zoning for other activities such as shipping, recreation, and mooring. These zones may help reduce conflict among user groups, maximize economic efficiency and also provide conservation benefits. For example, mooring zones can reduce damage to the reef and other seabed resources (Douvere, 2008; Ehler, 2008).

Zones can also be used to encourage economic development by clearly marking areas that can be used for specific activities (Douvere, 2008; Ehler, 2008). One example is aquaculture which can conflict with other ocean uses and therefore designating aquaculture zones can help incentivize development (Sanchez-Jerez et al., 2016; Lester et al., 2018). Aquaculture, if developed in an environmentally sustainable way, could reduce pressure on local fisheries while providing a source of fresh, local seafood and employment opportunities. Marine spatial planning provides a mechanism for balancing economic development and human use with environmental conservation, ensuring a sustainable and more prosperous blue economy over the long-term.

VIII. Appendix

The implementation of MPAs and no-take areas have been shown to have several advantages, and also some disadvantages, especially in the short-term (Table 1).

Table 1. Overview of Research Papers on the Effects of No-Take Protected Areas

NO TAKE AREAS	Short-term	Long-Term	Reference (Examples)
BENEFITS			
Ecological			
Protection of marine biodiversity	x	x	Mumby et al. 2007
Reduction of extinction risk of keystone species		x	Davison and Dulvy 2017
Reduction of fishing pressures	x	x	Hughes et al. 2003
Increase biomass of herbivores and carnivores	x	x	Mumby et al 2007
Increase fish available for consumption		x	Hughes et al. 2003, Edgar et al. 2014
Help maintaining key ecosystem processes		x	Game et al. 2009
Improve ecosystem resilience		x	Hughes et al. 2007b
Mitigation of drivers leading to ecosystem change		x	Machumu and Yakupitiyage 2013
Better management of ecosystems goods and services		x	Leenhardt et al. 2015
Socioeconomic			
Protection of cultural heritage		x	Game et al 2009
Increase of local people income and food	x	x	Dixon 1993
Increase sustainability of country's assets	x	x	Dixon 1999, Game et al. 2009
Enhance tourism benefits	x	x	Dixon 1999, Game et al. 2009, Chae et al. 2012
Scientific			
Opportunity to assess short-long term effects of management	x	x	Halpern et al. 2010
Assist conservation based on best knowledge		x	Fox et al. 2011
IMPROVED IF			
(1) Proper enforcement			Edgar et al. 2014
(2) Presence of No-Take areas within the MPA			Edgar et al. 2014
(3) MPAs are large			Edgar et al. 2014
(4) MPAs are old			Edgar et al. 2014
(5) MPAs are isolated by sandy deep habitats			Edgar et al. 2014
(6) Species-specific management actions implemented			Edgar et al. 2014

NO TAKE AREAS	Short-term	Long-Term	Reference (Examples)
DISADVANTAGES			
Positive results often noticeable only in the long-term	x		Selig and Bruno 2010
Proper implementation requires investment (enforcement)	x		Selig and Bruno 2010
Conflicts of use between stakeholders	x		Davos et al. 2007
Lack of rules of thumb to create and desig marine protected areas	x	x	Agardy et al. 2003
ENHANCED IF			
Evidence to support MPAs benefits is contradictory			McClanahan et al. 2006
Lack of education programs to show advantages			Davos et al. 2007
Reluctance of fisherman to accept MPAs			Davos et al. 2007
Poor criteria for establishing size, boundaries and location of MPAs			Edgar et al. 2014
Poor governance/poverty			Lopes et al. 2014
Ignorance of local realities and stakeholders needs			Davos et al. 2007, Lopes et al. 2014

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