Marine Protected Areas: benefits to people and nature

Ecological Benefits

Increased species size, abundance and biomass

One of the most consistently documented ecological benefits of MPAs is the increase in size, biomass, and diversity of marine life within protected area boundaries and beyond. When fishing pressure is restricted or fully removed, populations of exploited species are given the necessary space and time to grow larger, live longer, and reproduce more frequently.

Numerous studies monitoring the effects of MPAs have documented benefits to species richness, biomass, organism size, fecundity, and community structure[1,2,3]. A meta-analysis of 124 fully protected MPAs around the world revealed that, on average, fish biomass was 4.5 times higher, body size 28% larger, and species richness 21% higher within MPAs compared to adjacent unprotected areas[3]. This study also highlights that while partially protected areas may provide some benefits, fully no-take MPAs generally yield greater gains. Moreover, large-bodied and top predator species often show the most dramatic increases within MPAs[4,5]. These species like groupers[6] and snappers[7] play key roles in maintaining the balance and structure of marine food webs. Thus, increases in the biomass of large predator species is linked to a shift in marine food webs to a more mature state, ultimately enhancing ecosystem resilience.

While MPAs across Canada are relatively new and lack comprehensive monitoring, cases of their impacts are beginning to emerge. For instance, Heiltsuk, Kitasoo/Xai'Xais, Nuxalk, and Wuikinuxv First Nations have conducted research on Dungeness crab *(Cancer magister)* in their territories along the Central Coast of BC, in response to declining catch rates. This study found that the body size and catch-per-unit effort of male Dungeness crabs increased over time at the ten sites closed to commercial and recreational fishers, while declining at open sites[8].

These findings align with similar patterns along the Pacific coast of North America. For example, a study from the Santa Barbara Channel Islands MPA network in California found that within 5-6 years of its establishment, there was a 5-10% increase in mean size of spiny lobsters within the MPAs compared to adjacent fished areas, resulting in a four- to eight-fold increase in catch[9]. This increase in species size, along with rising abundance of marine life contributes to greater productivity and resilience across the entire ecosystem.

Ecosystem resilience and recovery

MPAs help maintain ecosystem stability and function while also supporting the recovery of degraded habitats. By removing stressors such as bottom trawling, anchoring, and other industrial activities, these areas provide ecosystems with the space and time they need to regenerate and rebuild. A primary way MPAs contribute to habitat recovery is by protecting habitat-forming species such as eelgrass beds, kelp forests, and coral and sponge reefs[10,11]. These species create physical structures that provide food, shelter, and breeding grounds for a wide range of marine life, making them critical for maintaining and enhancing marine biodiversity.

For example, in 2014, an MPA in southwest UK waters was established to protect Eddystone Reef from damage caused by bottom-contact fishing[12]. Monitoring of this site found that the MPA supported a greater abundance of slow growing reef species such as pink sea fan, ross coral, and branching sponges compared to adjacent fished areas. The protection of these key benthic species will likely enhance structural complexity, reduce reef habitat fragmentation and increase marine biodiversity over time.

Beyond habitat protection, MPAs enable the recovery of slow-growing, long-lived species such as rockfish and abalone. For example, in Baja California, abalone populations within MPAs maintained stable recruitment levels and adult densities despite widespread mortality from climate-driven hypoxia, highlighting the role of MPAs in buffering species against environmental stress[13]. Sustained, long-term protection is essential for the recovery of these species.

MPAs also serve as refugia for overharvested species and those at risk of extinction or collapse. By reducing cumulative impacts and protecting critical habitats such as spawning grounds, nursery habitats, and key feeding areas essential to the life cycle of marine species, MPAs enhance the chances of population recovery. In Australia's Great Barrier Reef, reduced fishing pressure within MPAs led to the increased stability, resistance, and recovery of coral reef communities[11]. Over 20 years, coral recovery within MPAs was 20% faster than in adjacent unprotected areas, demonstrating how MPAs can increase reef resilience to disturbances such as coral bleaching and coral disease through trophic cascades and portfolio effects.

Climate Mitigation

Climate change is reshaping the ocean, putting marine fish stocks and fisheries at risk. Its direct and indirect effects send ripple effects through marine ecosystems, driving shifts in species distribution, altering the timing of key biological events, and transforming the structure and function of entire ecosystems[14]. In addition to conserving biodiversity, MPAs can contribute to climate change mitigation and adaptation. While MPAs alone cannot halt or reverse the impacts of climate change and offer limited protection against stressors such as ocean warming and acidification[15], they remain a low-risk strategy for safeguarding biodiversity and enhancing ecosystem resilience.

One of the most direct ways MPAs contribute to climate mitigation is through the protection of blue carbon ecosystems[16,17] such as seagrass, salt marshes, and mangroves. These coastal and marine habitats capture and store significant amounts of carbon while supporting biodiversity and coastal protection[18]. Growing research also highlights the significant role of seafloor sediment in organic carbon storage, with the potential to accumulate approximately 126–350 Mt of organic carbon annually[19]. When left undisturbed, blue carbon habitats often sequester carbon at higher rates per unit area than terrestrial forests and can lock it away in centuries. However, when degraded through activities like dredging, bottom-trawling, or coastal development, these habitats can release stored carbon back into the atmosphere as CO_2. By restricting such damaging activities, MPAs enhance the long-term carbon storage potential of these ecosystems.

Blue carbon ecosystems and other coastal habitats such as wetlands, mangroves, and coral reefs also effectively buffer shorelines and protect coastlines from rising seas and storm impacts[20]. For example, salt marshes can help reduce wave energy and height by around 82% and 61%, respectively[21]. Preserving the health and function of these ecosystems is key to maximizing their role in protecting coastlines from the impacts of sea level rise, storm surges, and erosion.

Understanding the extent to which no-take MPAs can rebuild biomass under climate change within the no-take MPAs borders and its surrounding waters is still limited. A growing body of literature suggests the need to incorporate climate-informed indicators and consider the climate-driven shifts of species in the design of MPAs[22]. A recent study used a climate-fish-fishing model to simulate the impacts of no-take MPAs on biomass and potential catches of 231 exploited fish and invertebrate species across the Northeast Atlantic[23]. The results show that no-take MPAs together with conservation-focused fisheries management can help offset the projected average 5-15% per degree Celsius loss of individual stock biomass under a 2.6-2.9°C global warming. And while climate change may increase the vulnerability of some fish stocks even with MPAs in place, they still have the valuable role as a refuge, buffering against climate-induced declines and supporting long-term fisheries sustainability.

As climate change continues to alter marine ecosystems worldwide, reducing anthropogenic stressors can help marine ecosystems recover, sustain vital ecosystem services, and enhance the capacity for marine life to withstand and adapt to stressors.

Citations

[1] Halpern, B. S. (2003). The impact of marine reserves: do reserves work and does reserve size matter?. *Ecological applications*, *13*(sp1), 117-137.

[2] Gell, F. R., & Roberts, C. M. (2003). Benefits beyond boundaries: the fishery effects of marine reserves. Trends in ecology & evolution, 18(9), 448-455.

[3] Lester, S. E., Halpern, B. S., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B. I., Gaines, S. D., ... & Warner, R. R. (2009). Biological effects within no-take marine reserves: a global synthesis. Marine Ecology Progress Series, 384, 33-46.

[4] García-Rubies, A., Hereu, B., & Zabala, M. (2013). Long-term recovery patterns and limited spillover of large predatory fish in a Mediterranean MPA. PLoS One, 8(9), e73922.

[5] Selden, R. L. et al. (2017) 'Protection of large predators in a marine reserve alters size-dependent prey mortality', Proceedings of the Royal Society B: Biological Sciences, 284(1847). doi: 10.1098/rspb.2016.1936.

[6] Hackradt, C. W., García-Charton, J. A., Harmelin-Vivien, M., Perez-Ruzafa, A., Le Direach, L., Bayle-Sempere, J., ... & Valle, C. (2014). Response of rocky reef top predators (Serranidae: Epinephelinae) in and around marine protected areas in the Western Mediterranean Sea. PLoS One, 9(6), e98206.

[7] Malcolm, H. A., Schultz, A. L., Sachs, P., Johnstone, N., & Jordan, A. (2015). Decadal changes in the abundance and length of snapper (Chrysophrys auratus) in subtropical marine sanctuaries. PloS one, 10(6), e0127616.

[8] Frid, A., McGreer, M., & Stevenson, A. (2016). Rapid recovery of Dungeness crab within spatial fishery closures declared under indigenous law in British Columbia. Global Ecology and Conservation, 6, 48-57.

[9] Lenihan, H. S., Gallagher, J. P., Peters, J. R., Stier, A. C., Hofmeister, J. K., & Reed, D. C. (2021). Evidence that spillover from Marine Protected Areas benefits the spiny lobster (Panulirus interruptus) fishery in southern California. Scientific Reports, 11(1), 2663.

[10] Howard, J., McLeod, E., Thomas, S., Eastwood, E., Fox, M., Wenzel, L., & Pidgeon, E. (2017). The potential to integrate blue carbon into MPA design and management. Aquatic Conservation: Marine and Freshwater Ecosystems, 27, 100-115.

[11] Mellin, C., Aaron MacNeil, M., Cheal, A. J., Emslie, M. J., & Julian Caley, M. (2016). Marine protected areas increase resilience among coral reef communities. Ecology letters, 19(6), 629-637.

[12] Pikesley, S. K., Solandt, J. L., Trundle, C., & Witt, M. J. (2021). Benefits beyond'features': Cooperative monitoring highlights MPA value for enhanced seabed integrity. Marine Policy, 134, 104801.

[13] Smith, J. G., Free, C. M., Lopazanski, C., Brun, J., Anderson, C. R., Carr, M. H., ... & Caselle, J. E. (2023). A marine protected area network does not confer community structure resilience to a marine heatwave across coastal ecosystems. *Global Change Biology*, *29*(19), 5634-5651.
[14] Poloczanska, E. S., Burrows, M. T., Brown, C. J., García Molinos, J., Halpern, B. S., Hoegh-Guldberg, O., ... & Sydeman, W. J. (2016). Responses of marine organisms to climate change across oceans. Frontiers in Marine Science, 3, 62.

[15] Bates, A. E., Cooke, R. S., Duncan, M. I., Edgar, G. J., Bruno, J. F., Benedetti-Cecchi, L., ... & Stuart-Smith, R. D. (2019). Climate resilience in marine protected areas and the ‘Protection Paradox’. Biological Conservation, 236, 305-314.

[16] Micheli, F., Saenz-Arroyo, A., Greenley, A., Vazquez, L., Espinoza Montes, J. A., Rossetto, M., & De Leo, G. A. (2012). Evidence that marine reserves enhance resilience to climatic impacts. PloS one, 7(7), e40832.

[17] Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., ... & Serrano, O. (2012). Seagrass ecosystems as a globally significant carbon stock. Nat Geosci 5: 505–509.

[18] Merwin, Anne, Sarah R. Cooley, Joshua D. McBee, Gwynne Taraska, Anna Zivian, and Chris Robbins. “‘Climate-Smart’ Marine Protected Areas for Mitigation and Adaptation Policy.” Ocean Conservancy, June 2020.

[19] Epstein, G., Fuller, S. D., Hingmire, D., Myers, P. G., Peña, A., Pennelly, C., & Baum, J. K. (2024). Predictive mapping of organic carbon stocks in surficial sediments of the Canadian continental margin. Earth System Science Data, 16(5), 2165-2195.

[20] Spalding, M. D., Ruffo, S., Lacambra, C., Meliane, I., Hale, L. Z., Shepard, C. C., & Beck, M. W. (2014). The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. Ocean & Coastal Management, 90, 50-57.

[21] Möller, I., Spencer, T., French, J. R., Leggett, D. J., & Dixon, M. (1999). Wave transformation over salt marshes: a field and numerical modelling study from North Norfolk, England. Estuarine, Coastal and Shelf Science, 49(3), 411-426.

[22] Bryndum-Buchholz, A., Eddy, T. D., & Fisher, J. A. (2025). Assessing indirect biodiversity conservation benefits of fisheries closures in the Gulf of St. Lawrence, Canada. PloS one, 20(1), e0316754.

[23] Cheung, W. W., Palacios-Abrantes, J., & Roberts, S. M. (2024). Projecting contributions of marine protected areas to rebuild fish stocks under climate change. npj Ocean Sustainability, 3(1), 11.