

Marine Protected Areas: An Effective Tool for Biodiversity Conservation?

Introduction

Marine Protected Areas (MPAs) are areas of the ocean established to protect habitats and species by restricting human activity, therefore reducing damage to the ecosystem. There are different types of MPAs, each providing varying levels of protection, from enforced quotas and no-take areas, to strictly no-entry zones. In the UK, there is a subset of MPAs known as Highly Protected Marine Areas, or HPMAs, and these provide the greatest level of protection, covering all species and habitats, from seabeds, to shore, and surface within the site boundary (Marine Management Organisation, 2023).

Marine ecosystems risk damage from many threats, some of the most pertinent being overfishing, water pollution, and climate change. MPAs can be established in several aquatic habitats, including lakes, open water and coastlines. Yet despite 71% of the Earth being covered in water, only around 8% of this is classed as 'protected' (Rutledge K. et al., 2024). Many government initiatives exist to extend the reach of these areas, as well as establishing new MPAs around the world, an example of this being the 30by30 aims outlined in the Kunming-Montreal Global Biodiversity Framework adopted during the 2022 UN Biodiversity Conference (COP15). The core goals being to ensure 30% of the ocean is designated as 'protected' by 2030, specifically through the establishment of MPAs (Global Ocean Alliance, no date).

Threats to Aquatic Biodiversity

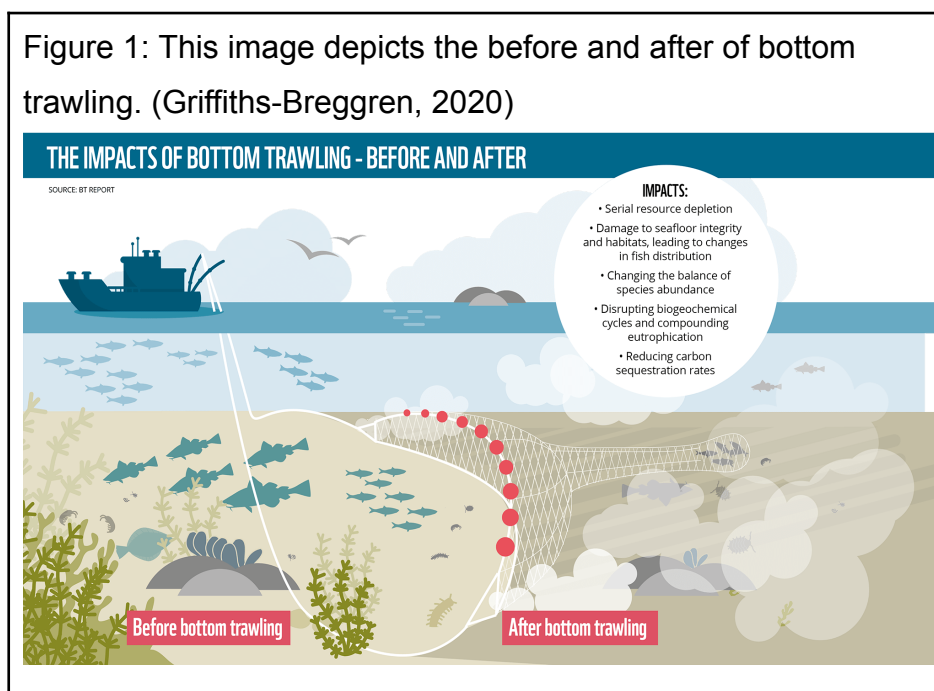
The ocean produces roughly half of the oxygen that we breathe (Regaudie-de-Gioux, 2024). Aside from sustaining livelihoods, providing food and creating habitats, it also plays a crucial role in climate regulation- acting as a major carbon dioxide sink (National Geographic, 2025). However, the ocean is under threat, with the majority of which being a direct result of human activity.

Overfishing is the term used when too large of a proportion of a particular stock is caught and therefore can't breed to sustain a healthy population. This process, often caused by overexploitation from commercial fisheries, can have major impacts on communities reliant on fishing, and global industry and can cause a significant loss of ocean biodiversity (Marine Stewardship Council, 2025). In 2017, a reported 34% of global fish stocks were overfished, meaning in subsequent years populations struggled to reach sustainable levels (Ritchie & Roser, 2021).

Evidence of the impacts of overfishing can be found in parts of the Caribbean where the overfishing of herbivorous fish- mainly parrotfish and surgeonfish- have major impacts on coral reef health. These species typically eat algae, keeping surfaces clear so new coral can grow. When overfished, algae are left free to grow, outcompeting the corals and causing a decline in all reef related species, such as sponges, crustaceans and other reef fish which all live as part of the typical ecosystem. As an attempt to mitigate this damage, many countries in the Caribbean have established Marine Protected Areas which impose strict fishing regulations and quotas to allow fish stocks to recover (Adam et al., 2015).

Destructive fishing practices, such as trawling, can have irreversible effects on marine ecosystems, with trawling nets often being described as underwater bulldozers. It's an industrial method that works by large boats dragging heavy, weighted nets along the

seafloor. Bottom trawlers are able to efficiently harvest large amounts of seafood, although with this they also pull up root systems and cause damage to coral reefs, sponge beds and seagrass meadows (Villasante, 2010). The disturbance of the sediments during these practices have



also been found to release previously stored carbon back into the water, supposedly contributing to ocean acidification and consequently undoing climate regulation services that the ocean has been providing. However, this carbon release impact is still an active area of research (Sala, et al., 2021), so data is still uncertain, and still lacking conclusive evidence of climate impacts. With some sources finding no significant effect from 61% of investigations, theorising the cause of increased CO₂ in the atmosphere being the trawling boats themselves (Epstein, 2022).

MPA Mechanisms

As mentioned previously, MPAs can be used to mitigate damage from potential threats to the ocean, and they do this with differing levels of severity depending on the issue. Each type of MPA employs varying mechanisms in order to preserve biodiversity and protect vulnerable species.

No-Take Zones (NTZs)

In the UK, known as Highly Protected Marine Areas (HPMAs), they offer some of the strictest environmental protections, prohibiting activities such as: commercial and recreational fishing, dredging, construction and anchoring. (Department for Environment, Food & Rural Affairs, 2023). These are widely considered to be the most effective method of protecting marine ecosystems, however they are often confused as being examples of 'fortress protection'. This model of environmental protection advocates for the total exclusion of human activity from the ecosystem, including the local communities (Dobson, personal communications, 2025). This model is often criticised for human rights violations, disproportionately impacting indigenous communities, who have been using the land sustainably for decades, of their land and source of food, without providing alternative sources of income or livelihood, often resulting in forced resettlement (The Oakland Institute, no date).

Furthermore, poorly designed MPAs can shift fishing pressure to surrounding, non-designated areas, in a phenomenon known as 'fishing the line'. This potentially concentrates exploitation on the boundaries of protected ecosystems and can consequently impact the designated areas biodiversity (Chen, 2020). Population sizes closer to the border in MPAs have been found to be 60% smaller than those in the core, on

the other hand, when a 'buffer zone' was introduced, there were no displayed edge effects. Providing evidence that no-take areas should extend beyond the target habitat areas in order to preserve biodiversity across the whole ecosystem (Ohanyon, et al., 2021).

Quotas, Seasonal Closures, and Gear Limits

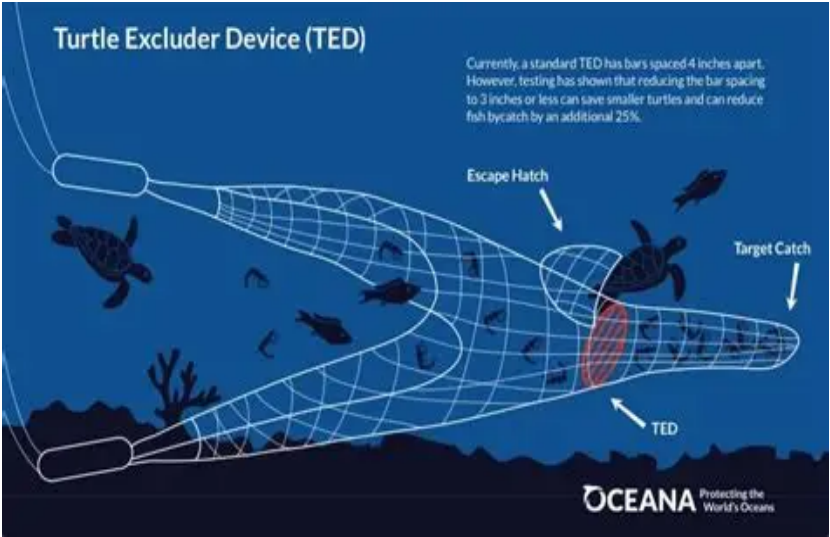
Quotas are one of the most common management tools used within the majority of conservation efforts. Their purpose is to regulate the amount of fish caught by commercial fisheries, in order to prevent overexploitation. They can apply to specific species, geographical areas, or fishing methods over a specific time frame. The number, or weight of fish is determined by an allocation process, producing a total allowable catch (TAC) value, set based on scientific assessments of fish populations (da Rocha, et al., 2013). They work well, finding the balance between conservation efforts and the fishing industry, for example after the North Atlantic Cod stock crash, carefully monitored quotas were used to restore populations- whilst simultaneously supporting long term fisheries (Nelson, 2015). However, the primary issue with quotas is that they are easily bypassed. Illegal, Unreported and Unregulated (IUU) fishing practices undermine quota limits and are very common around the world and this often simply leads back to overfishing practices.

Seasonal Closures work in tandem with quotas, temporarily restricting fishing practices when migration or spawning occurs. They are often used to help replenish populations after a quota has been met. Often the ecological calendars have to be developed with local communities, but they often create short term challenges for locals as alternative livelihoods are not always available. Since 1960, Texas has imposed a seasonal closure for the 45-60 day migration of brown shrimp through the Gulf of Mexico. The aim of this being to allow shrimp to grow to valuable sizes and a sustainable population level (FAO, no date)

Bycatch is the primary concern of trawling for biodiversity conservation, it refers to the "marine life unintentionally captured or entangled in commercial fishing equipment" (IFAW, 2025) and affects a large number of aquatic species. This significantly disrupts the ecosystem by removing key species that provide ecological balance; marine food webs, population structures and habitats are thrown into disarray, resulting in an overall reduction

of species richness and overall biodiversity. In an attempt to alleviate biological impacts, MPAs have been established with strict no trawling regulations, where instead alternative fishing practices are encouraged, such as Turtle Excluder Devices (TEDs) and other Bycatch Reduction Devices (Werner, et al. 2006; IFAW, 2025). Gear limits are often easier to enforce as the physical presence of illegal gear is more readily detectable.

Figure 2: This image depicts a Turtle Excluder Device typically used in MPAs with shrimp quotas (Oceana, no date).



Increasing the net-mesh size is a relatively easy change which can be implemented in MPAs in order to reduce the capture of juveniles (Oceana, no date). In 2012, a study was conducted, measuring the abundance of discards required when different net mesh sizes were used. Fish and invertebrates are discarded when they do not meet commercial size requirements, or quotas criteria. It was found that when using 20mm mesh, 40% of catches are discarded, compared to only 16% when using the 24mm mesh (Tarantino, et al., 2024). This is significant as fewer discards means there is less impact on the fish stock, the juvenile fish are able to support the population sizes (Lively & McKenzie, 2023).

Figure 3: Depicts a table evidencing the impact of net size on discard abundance (Tarantino, et al., 2024)

Discards (Abundance)						
Mesh	20 mm		22 mm		24 mm	
Group	Comm	Disc	Comm	Disc	Comm	Disc
Inv	282	17	394	17	738	405
Fish	3002	2174	2766	1571	1411	5
tot	3284	2191	3160	1588	2149	410
Discards	20 mm		22 mm		24 mm	
Inv	0.05		0.04		0.006	
Fish	0.42		0.36		0.22	
Tot	0.40		0.33		0.16	

Comm, Commercial size; Disc, Discard size.

‘Paper Parks’

These are MPAs which strictly exist on paper, or in other words, they have no significant mechanisms in use to ensure the integrity of its protected status (Dobson, personal communications, 2025). Their purpose being to fulfil legislation requirements, being officially designated on maps and reported in global statistics, yet providing no ecological protection. A study by Oceana (2020) found that nearly three-quarters of European MPAs assessed were affected by one or more threats, despite their protected status. These, and many others around the world, had been established for political visibility rather than ecological outcomes. Paper parks not only fail to protect marine biodiversity, but also can diminish public trust- the lack of ecological results could dissuade possible conservation initiatives in the future. (Oceana, 2020; Dobson, personal communications, 2025)

This issue is particularly pressing in the context of the 30by30 global conservation targets. While expansion of protected areas is important, simply increasing coverage without ensuring effective management would just worsen the social opinion of climate goals, evidencing the unrealistic aims would only negatively impact all climate initiatives. Studies already suggest that we are not on track to meet these climate goals (Mouterde, 2024) so the result is likely to be seen as another conservation failure, either because they fail to designate 30% of the ocean, or because nations will rush to designate large open areas of ocean as MPAs, effectively creating a sea of paper parks (Dobson, personal communications, 2025).

Case Study- Ras Mohammed

Marine Protected Areas vary widely in their design and effectiveness, with some delivering measurable ecological goals, and others remaining no more than symbolic gestures. The Ras Mohammed, a National Park and MPA located at the apex of the Sinai Peninsula, is known for being “one of the world's top 10 sites recognised for effective management of marine ecosystems” (IUCN, 2018) and is a perfect example for an effectively managed Marine Protected Area. Only around 3km² of the area is designated officially no-take and for the rest of the park, very strict fishing quotas and restrictions are in place, with controlled access to the waters being provided, including guided diving researchers- only 12% of the National park is permitted for tourism (IUCN, 2018). The MPA is overseen by the Egyptian Environmental Affairs Agency, however what sets the Ras Mohammed apart

is the support from the local community. Eco-tourism is locally managed by Bedouin communities- nomadic Arab peoples and natives. Inside the park, reefs average over 65% live coral coverage, compared to just 20-30% outside the reserve (Global Environment Facility, 2022). The reason this case study is considered an effective marine protected area, is that it encompasses the needs of the local people, whilst also implementing manageable restrictions which encourage successful biodiversity regeneration (Dobson, personal communications, 2025).

The Ras Mohammed demonstrates how the success of an MPA lies not in their size, but in their enforcement, ecological monitoring, and community support. By considering all these factors, this park models how MPAs can deliver tangible results and also shows how simply meeting numerical coverage goals, like the 30by30 aims, is insufficient.

Conclusion

In evaluating the effectiveness of Marine Protected Areas, it is clear that ecological conservation outcomes are variable dependent on governance, policing, and community integration. While MPAs such as the Ras Mohammed demonstrate exceptional biodiversity improvement results, many others- particularly European 'paper parks' highlight how simply legally designating an area does not mean anything for the ecosystem.

Mechanisms and management tools such as quotas, seasonal closures and no-take zones all offer benefits for species recovery and protection, when properly implemented.

Ultimately, MPAs can be one of, if not the most effective methods of preserving marine biodiversity, but only when properly designed and enforced with ecological integrity, strong governance, enough funding and the support of local communities at its core.

Appendix: Interview (abbreviated)

Interviewee: Angus Dobson, MSci Marine Biology

Date: 10/07/2025

Key Questions & Responses-

1.) What constitutes a well managed MPA?

“One of the biggest problems with MPAs is managing their protected status, because we are dealing with such large areas it can become quite difficult to police them.. A ‘bad’ marine protected area, or what some might call paper parks, are those which exist just to fulfil a legislation, meaning they just designate a random area of water as protected, and yet have no actual way to insure the integrity of its protected status”

2.) How should local communities be considered?

“What needs to be considered when evaluating an effective MPA is that it encompasses local needs. The land you designate could be the source of livelihood for a small village, or the fishery where an indigenous population have gained sustenance for the last 4 centuries. It is important that these are taken into account when setting up specifically no-take and no-go areas as this fortress conservation can have dire impacts on these local communities, who themselves are not the main contributor to overfishing and unsustainable use of this land. They have been using it sustainably since before we knew what that word meant.” ...“You have to engage the local population, any money made from eco-tourism should go back into the pockets of those who have been limited by the enforcement of the area.

3.) From your experience, how effective are MPAs?

“I spent some time studying biodiversity in MPAs specifically along the Apex of the Sinai Peninsula. The Red Sea has some of the most diverse coral reefs on the planet and we were investigating specifically the Ras Mohammed National Park, which covers both terrestrial and marine environments. It is a strictly protected MPA, on land with armed guards and it is a strict no-go for those without designated access, such as our research team.”... “We were surveying local diving sites and comparing them to the Ras Mohammed, and the difference was immediately noticeable. The increase in species richness was like day and night.”

References-

- Adam, T. C., Burkepile, D. E., Ruttenberg, B. I., & Paddock, M. J. (2015). Herbivory and the resilience of Caribbean coral reefs: Knowledge gaps and implications for management. In *Marine Ecology Progress Series* (Vol. 520, pp. 1–20). Inter-Research. Available at: <https://doi.org/10.3354/meps11170> [Accessed 15/08/2025]
- Chen, R., Baskett, M. L., & Hastings, A. (2020). *Fishing the line depends on reserve benefits, individual losing at boundary and movement preference*. Available at: <https://doi.org/10.1101/2020.09.15.299032> [Accessed 18/08/2025]
- da Rocha, J. M., Villasante, S., & González, R. T. (2013). Credible Enforcement Policies Under Illegal Fishing: Does Individual Transferable Quotas Induce to Reduce the Gap Between Approved and Proposed Allowable Catches? *Ambio*, 42(8), 1047. Available at: <https://doi.org/10.1007/S13280-013-0459-6> [Accessed 17/08/2025]
- Department for Environment, F. & R. A. (2023, May 25). *Highly Protected Marine Areas (HPMAs) - GOV.UK*. Available at: <https://www.gov.uk/government/publications/highly-protected-marine-areas/highly-protected-marine-areas-hpmas#how-we-will-manage-pilot-hpmas> [Accessed 14/08/2025]
- Dobson, Angus (2025). Private Interview as part of the TechFest's STEM Next Essay Competition. Interview by AUTHOR, 10 July 2025
- Epstein, G., Middelburg, J. J., Hawkins, J. P., Norris, C. R., & Roberts, C. M. (2022). The impact of mobile demersal fishing on carbon storage in seabed sediments. *Global Change Biology*, 28(9), 2875–2894. Available at: <https://doi.org/10.1111/GCB.16105;JOURNAL:JOURNAL:13652486;WGROU:STRING:PUBLICATION> [Accessed 17/08/2025]

FOA. (n.d.). *PAPERS PRESENTED at the EXPERT CONSULTATION ON THE REGULATION OF FISHING EFFORT (FISHING MORTALITY)*. Available at:

<https://www.fao.org/4/ac750e/AC750E13.htm> [Accessed 20/08/2025]

Global Ocean Alliance. (n.d.). *Global Ocean Alliance - GOV.UK*. Available at:

<https://www.gov.uk/government/topical-events/global-ocean-alliance-30by30-initiative/about>

[Accessed 14/08/2025]

Griffiths-Berggren, H. (2020, December 2). *Bottom trawling in the Baltic: too much damage - WWF Baltic*. Available at:

<https://www.wwfbaltic.org/newsroom/fisheries/bottom-trawling-in-the-baltic-too-much-damage>

[Accessed 17/08/2025]

IFAW. (2024, July 24). *What is bycatch & why is it so harmful? | IFAW*. Available at:

<https://www.ifaw.org/international/journal/bycatch> [Accessed 17/08/2025]

IUCN. (n.d.). *IUCN Green List Ras Mohammed National Park - IUCN Green List*. Available at: <https://iucngreenlist.org/sites/ras-mohammed-national-park/> [Accessed 20/08/2025]

IUCN. (2018, December 3). *Ras Mohammed National Park: Egypt's underwater paradise among the best protected marine reserves on the planet | IUCN*. Available at:

<https://iucn.org/news/protected-areas/201812/ras-mohammed-national-park-egypts-underwater-paradise-among-best-protected-marine-reserves-planet> [Accessed 20/08/2025]

Kleinhaus, K., Al-Sawalmih, A., Barshis, D. J., Genin, A., Grace, L. N., Hoegh-Guldberg, O., Loya, Y., Meibom, A., Osman, E. O., Ruch, J. D., Shaked, Y., Voolstra, C. R., Zvuloni, A., & Fine, M. (2020). Science, Diplomacy, and the Red Sea's Unique Coral Reef: It's Time

for Action. *Frontiers in Marine Science*, 7. Available at:
<https://doi.org/10.3389/FMARS.2020.00090/FULL> [Accessed 20/08/2025]

Lively, J. A., & McKenzie, J. (2023). Discards and bycatch: A review of wasted fishing. *Advances in Marine Biology*, 95, 1–26. Available at:
<https://doi.org/10.1016/BS.AMB.2023.07.001> [Accessed 17/08/2025]

Marine Management Organisation. (2023, March 13). *Marine Protected Areas (MPAs)* - GOV.UK. Available at: <https://www.gov.uk/guidance/marine-protected-areas-mpas> [Accessed 14/08/2025]

Marine Stewardship Council. (2025). *What is overfishing* | Marine Stewardship Council. Available at: <https://www.msc.org/uk/what-we-are-doing/what-is-overfishing> [Accessed 17/08/2025]

Mouterde, P. (2024, October 29). *Biodiversity: The world is not on track to protect 30% of land and sea by 2030*. Available at:
https://www.lemonde.fr/en/environment/article/2024/10/29/biodiversity-the-world-is-not-on-track-to-protect-30-of-land-and-sea-by-2030_6730877_114.html [Accessed 21/08/2025]

National Geographic. (2025, August 22). *Oceans and the threats they face* | National Geographic. Available at:
<https://www.nationalgeographic.com/environment/article/ocean-threats> [Accessed 24/08/2025]

Nelson, A. (2015, September 25). *North Sea cod could be back on menu as numbers improve* | Fishing | *The Guardian*. Available at:
<https://www.theguardian.com/uk-news/2015/sep/25/north-sea-cod-taken-off-red-list-of-fish-to-avoid-as-numbers-improve> [Accessed 18/08/2025]

Oceana. (n.d.). *ted_graphic*.

Oceana. (2020a). *Unmanaged = Unprotected: Europe's marine paper parks - Oceana Europe*. Available at:

<https://europe.oceana.org/reports/unmanaged-unprotected-europes-marine-paper-parks/>

[Accessed 25/08/2025]

Oceana. (2020b, December 14). *Unmanaged = Unprotected: Europe's marine paper parks - Oceana Europe*. Available at:

<https://europe.oceana.org/reports/unmanaged-unprotected-europes-marine-paper-parks/>

[Accessed 25/08/2025]

Ohayon, S., Granot, I., & Belmaker, J. (2021). A meta-analysis reveals edge effects within marine protected areas. *Nature Ecology and Evolution*, 5(9), 1301–1308. Available at:

<https://doi.org/10.1038/S41559-021-01502-3> [Accessed 22/08/2025]

Regaudie-de-Gioux, A., Lasternas, S., Agustí, S., & Duarte, C. M. (2014). How much oxygen comes from the ocean? *Frontiers in Marine Science*, 1(JUL). Available at:

<https://doi.org/10.3389/FMARS.2014.00019> [Accessed 14/08/2025]

Ritchie, H., & Roser, M. (2021, October). *Fish and Overfishing - Our World in Data*.

Available at: <https://ourworldindata.org/fish-and-overfishing> [Accessed 24/08/2025]

Rutledge K., Teng S., Hall H., & McDaniel M. (2024, April 10). *The Importance of Marine Protected Areas (MPAs)*. Available at:

<https://education.nationalgeographic.org/resource/importance-marine-protected-areas/> [Accessed

14/08/2025]

Sala, E., Mayorga, J., Bradley, D., Cabral, R. B., Atwood, T. B., Auber, A., Cheung, W., Costello, C., Ferretti, F., Friedlander, A. M., Gaines, S. D., Garilao, C., Goodell, W., Halpern, B. S., Hinson, A., Kaschner, K., Kesner-Reyes, K., Leprieur, F., McGowan, J., ... Lubchenco, J. (2021). Protecting the global ocean for biodiversity, food and climate. *Nature*, 592(7854), 397–402. Available at: <https://doi.org/10.1038/S41586-021-03371-Z;SUBJMETA=172.704.829;KWRD=ENVIRONMENTAL+SCIENCES,OCEAN+SCIENCES> [Accessed 14/08/2025]

Tarantino, G., Motta, G., D'Ambrosio, P., Felling, S., Sbragaglia, V., Bevilacqua, S., Tedesco, P., Scordella, G., & Terlizzi, A. (2024). Increasing trammel mesh size reduces biomass removal, mitigates discards and increases economic revenue in artisanal fisheries. *Frontiers in Marine Science*, 11, 1267381. Available at: <https://doi.org/10.3389/FMARS.2024.1267381/BIBTEX> [Accessed 24/08/2025]

The Oakland Institute. (n.d.). *Fortress Conservation* | *The Oakland Institute*. Available at: <https://www.oaklandinstitute.org/issues/fortress-conservation> [Accessed 22/08/2025]

Villasante, S., do Carme García-Negro, M., González-Laxe, F., & Rodríguez, G. R. (2011). Overfishing and the Common Fisheries Policy: (un)successful results from TAC regulation? *Fish and Fisheries*, 12(1), 34–50. Available at: <https://doi.org/10.1111/J.1467-2979.2010.00373.X> [Accessed 17/08/2025]

Werner, T., Kraus, S., Read, A., & Zollett, E. (2006). *Fishing Techniques to Reduce the Bycatch of Threatened Marine Animals*. Available at: [\(PDF\) Fishing Techniques to Reduce the Bycatch of Threatened Marine Animals](#) [Accessed 18/08/2025]