frontiers | Frontiers in Marine Science

TYPE Editorial
PUBLISHED 15 August 2023
DOI 10.3389/fmars.2023.1250449

OPEN ACCESS

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RECEIVED 30 June 2023
ACCEPTED 04 August 2023
PUBLISHED 15 August 2023

CITATION
Sumaila UR, de Fontaubert C and Palomares MLD (2023) Editorial: How overfishing handicaps resilience of marine resources under climate change. *Front. Mar. Sci.* 10:1250449. doi: 10.3389/fmars.2023.1250449

Editorial: How overfishing handicaps resilience of marine resources under climate change

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KEYWORDS

overfishing, carbon emission, sequestration, small-scale, large-scale

Editorial on the Research Topic
How overfishing handicaps resilience of marine resources under climate change

It is now clear to most scientists and many non-scientists that Climate Change (CC) is altering ocean physics and chemistry, thereby affecting the ecology and biology of marine life. These changes in turn impact ocean economics and the lives and livelihoods of millions of people who depend on it. Independent and IPCC (Intergovernmental Panel on Climate Change) researchers have been developing this knowledge for decades (e.g., Cheung et al., 2010; Sumaila et al., 2011; Bopp et al., 2013; Pörtner et al., 2019).

In recent years, scientists and the world have come to realise that the interaction between CC and the ocean and its dependent economies are not unidirectional but bidirectional. That is, it is not just that CC impacts ocean life and related economies, but ocean economic activities also contribute to carbon emission and therefore CC. To demonstrate the latter in terms of fish and fisheries, researchers at the University of British Columbia in collaboration with the environmental NGO, Our Fish, launched a Research Topic to see if we could show that addressing overfishing is also in effect climate action. Over 40 scholars collaborated to author nine papers in this Research Topic entitled "*How Overfishing Handicaps Resilience of Marine Resources Under Climate Change*".

We describe here the highlights of each paper with the goal of whetting the appetite of the reader to dig deeper into our findings by reading the papers in full.

In the opening paper in the Research Topic, Sumaila and Tai explain how ending overfishing can increase the resilience of the ocean to CC. The authors conducted a literature review and analysis, and concluded that (i) marine fish stocks are overfished in many parts of our oceans; (ii) CC has significant consequences on ocean life; (iii) ending overfishing could make fish stocks more climate resilient; and (iv) fish and fish stocks are like people and more likely to withstand the impact of an attack (e.g., by CC) when they are in a healthy condition to start with.

Ferrer et al. make the powerful point that overfishing, often caused by large, subsidised fishing fleets (Sumaila et al., 2021; Skerritt et al., 2023), is a double whammy for small-scale fisheries (SSF). First, it forces people to spend more time burning fuel to search for scarcer,

overfished resources, which is both costly and risky. Second, the extra carbon emitted to chase fewer fish aggravates the contribution of CC to warming, ocean acidification and deoxygenation, all of which unduly impact fish and fisheries (Sumaila et al., 2019; Lam et al., 2020). The authors used long-term fisheries monitoring data from Northwest Mexico to test the relationship between underlying fishery biomass and fuel intensity observed among several motorised small-scale fisheries (SSF). Their study supports the double whammy conclusion for SSF.

Martin et al. addressed the question: what if depleted fish stocks worldwide were restored, how would this affect the level of carbon emissions? Clearly, this is an important question since, until recently, the literature had mainly concentrated on how much more biomass, catch, and profits would be generated if fish biomass were rebuilt and managed more effectively (Sumaila et al., 2012; World Bank, 2017; Teh and Sumaila, 2020). Using landings and effort data combined with estimates of adult population biomass, Martin et al. explore the potential for lowering emissions intensity and impacts on organic carbon stocks through ending overfishing and rebuilding stocks. Specifically, they use the recent recovery of European hake (*Merluccius merluccius*) stocks in the Northeast Atlantic as a case study. Their results suggest that recovery of the hake stock led to reductions in overall emissions intensity from fuel.

Scotti et al., focused on the western Baltic Sea, exploring how ecosystem-based fisheries management (EBFM) can increase catch and carbon sequestration through recovery of exploited stocks. In a nutshell, they found that by allowing fish stocks that have been overfished to recover, we can enjoy the double dividend of being able to catch more fish sustainably while at the same time increasing the ability of the large fish biomass to sequester more carbon. This study presents the first mass-balanced ecosystem model focused on the western Baltic Sea (WBS), and a more specific result generated by the study is that heavy fishing pressure exerted on the WBS has forced top predators such as harbour porpoise and cod to cover their dietary needs by shifting from forage fish to other prey, or to find food outside of the model area. In addition, they found that the EBFM scenario would allow the recovery of harbour porpoise, forage fish and cod with increases in catch of herring and cod. In addition, EBFM promotes ecosystem resilience to eutrophication and ocean warming, and through the rebuilding of commercial stocks, increases by more than three times carbon sequestration compared to the 'Business as Usual' scenario.

Issifu et al. developed a risk assessment and policy solution framework, which the authors used to evaluate the impact of ocean warming, overfishing and mercury on European fisheries. Their study suggests that the negative impacts of these stressors on European fisheries depend on the type of species being studied, and their mean temperature tolerance (MTT). These negative impacts may limit the capacity of fisheries and marine ecosystems to respond to current climate induced pollution sensitivity. The authors concluded that ongoing global efforts aimed at minimising carbon footprints and mercury emissions need to be enhanced in concert with an extensive drive to reduce fishing intensity. Such an integrated approach to tackling the combined effects of ocean warming, overfishing and mercury is needed to maintain effective conservation measures that promote increased resilience of fisheries to CC and other stressors.

Villasante et al. start by emphasizing the importance of SSF for livelihoods, food security, jobs, and income worldwide. The authors further make the point that these fisheries are facing serious challenges, including the increasing effects of CC that pose significant threats to coastal ecosystems and fishing communities. They carried out a case study based in Galicia (Spain), where they estimated the economic vulnerability of shellfishers and assessed the diversity of social adaptive responses used to deal with CC. Among other things, Villasante and his co-authors found that Galician shellfishers developed a wide range of adaptation strategies to anticipate and respond to CC impacts. These include targeting pricier and more abundant species, reducing household expenses, and increasing social involvement in shellfishery associations. Still, the locally developed adaptive strategies are not enough to insulate the shellfish fishers from the risks they face from CC and other threats.

Macusi et al. sought to determine how vulnerable a selection of SSF and associated fishing communities around the Davao Gulf in the Philippines are to CC. A semi-structured questionnaire was used to gather data on the perceptions of fishers on the impacts of CC on their livelihood and communities. The results of their analysis suggest that coral bleaching, inadequate food, lack of credit access, changes in weather patterns and hotter temperatures contributed highly to the vulnerability of the SSF. The authors report that CC contributes to less seasonality, unclear reproductive patterns, diseases in the catch, invasive species, decrease in catch as well as forcing SSFs to venture farther and deeper in the ocean to fish - aggravating CC as discussed in earlier papers in this Research Topic.

Oostdijk et al. discuss how to govern the open ocean so it can contribute its part to sequestering carbon. They highlight the vital service that fish, and other marine vertebrates provide in the biological pump, a topic that is now receiving more attention by both policy makers and scientists. The authors explored the interest in and possibilities for the establishment of international governance of the open ocean and the role that fish, and other marine vertebrates play as carbon sequesters. The authors used semi-structured interviews involving environmental non-governmental organization (ENGO) representatives, policy makers, and policy experts. This was supplemented by an exploratory review of grey and peer-reviewed literature with two objectives in mind. First, the authors traced the pathway of important key actors, and the strategies they use to influence the governance of ocean carbon. Second, they investigated different frameworks to determine which ones might be used to govern the open ocean and the fish carbon it sequesters. The authors conclude that more viable routes for future governance of the open ocean and the carbon sequestered by fish and other marine animals may lie in international fisheries management and in the negotiations of the treaty on Biodiversity Beyond National Jurisdiction (BBNJ) that were just concluded.

The final paper by Krabbe et al. suggests ideas on how international fisheries laws could be reformed to increase blue carbon sequestration. The authors emphasized the fact that the

climate services performed by the ocean can be described as an interaction between a physical and a biological carbon pump, and that the scale of interaction is yet to be fully understood. Currently many species in the open ocean and elsewhere in the marine ecosystem are managed under the international law of the sea and subject to the concept of Maximum Sustainable Yield (MSY). Under MSY-based management, states are not required to consider the climate services represented by different marine organisms, making this regime unable to balance the interest of maximizing fish as a product against the ocean's role in carbon sequestration. The authors argue that in order to make optimal use of the carbon sequestration features of marine organisms, a number of modifications to the current international law are urgently needed. Their top recommendation is that MSY should be complemented with a new management objective, which governs the open ocean to maximize carbon sequestration (MCS) rather than MSY. The authors conclude that reforming international fisheries law to achieve MCS could make an important contribution to the operationalization of the Paris Agreement on Climate Change, as well as the UN Sustainable Development Goals.

These papers taken together are greater than the sum of their parts, and we anticipate that the studies reported in this Research Topic, and the insights they provide, will contribute an important "missing link" to ongoing discussions on CC, marine ecosystems and how we best fish sustainably. Many of the papers alert us to the fact that fisheries are not just victims of CC but also contributors to its aggravation through overfishing. The important conclusion that overfishing contributes to the intensity of CC, which in turn makes fisheries more vulnerable and susceptible to CC, is a very important one for policy makers. Ultimately, this Research Topic also shows that addressing overfishing is a win-win, for ocean health, to address CC, and ultimately for the millions who depend on sustainable fisheries for jobs, food and nutritional security.

Author contributions

US wrote initial draft; CF and MP contributed equally. All authors contributed to the article and approved the submitted version.

Funding

We acknowledge the financial support of Our Fish, in particular, Rebecca Hubbard, Mike Walker and Dave Walsh. US also thanks the Solving FCB Partnership sponsored by the Social Sciences and Humanities Research Council of Canada (SSHRC).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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