Perspective

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Rethinking sustainability of marine fisheries for a fast-changing planet

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Many seafood products marketed as "sustainable" are not. More exacting sustainability standards are needed to respond to a fast-changing world and support United Nations SDGs. Future fisheries must operate on principles that minimise impacts on marine life, adapt to climate change and allow regeneration of depleted biodiversity, while supporting and enhancing the health, wellbeing and resilience of people and communities. We set out 11 actions to achieve these goals.

Healthy oceans are critical for nature, human wellbeing and planetary stability. Marine life, including exploited species, are essential to that health, driving biological, chemical and physical processes integral to ecosystem functioning and services to people[1,2]. Yet most countries are failing to meet targets under the Paris Agreement, the United Nations Sustainable Development Goals (SDGs) for poverty reduction, zero hunger and adequate nutrition, climate action, reduced inequalities, environmental and ocean protection[3], as well as the Global Biodiversity Framework[4]. To meet these global aspirations, we must move beyond business as usual, reimagine sustainability standards for fishing that will be resilient and adaptable in the face of rapid global change, and develop creative ways to implement them.

Marine fish contribute significantly to global food and nutritional security, particularly through subsistence, artisanal and commercial small-scale fisheries and in the Global South[5]. The healthier nutritional profile of seafood versus terrestrial animal foods has led to increased promotion of seafood[6] with the global rate of its consumption continuing to outpace that of human population growth[5] and projected to nearly double by 2050[7]. Today, wild seafood is sourced through an extraordinary diversity of social-ecological systems that operate from coastal habitats through to the open ocean and target a plethora of animals and plants[8]. Managing fisheries more sustainably is a global imperative given the increasing numbers of people living in hunger[9].

Many of the world's fish populations remain overfished and in decline[5,10], despite improvements in fisheries management and fishing practices for some species and in some countries[11]. Numerous fishing companies operate in ways that generate wide environmental impacts on

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ecosystems and habitats. Adding to these systemic problems, maximum sustainable yield (MSY), internationally recognised as the standard for sustainable fishing, is based on a single-species approach that takes into account neither interactions among species nor impacts on habitat or ecosystem roles played by target species[12]. Repeated calls and much evidence for the need for an ecosystem-based approach to fishery management[13,14] and guidance for its implementation[15] have had limited influence to date. The impacts of fishing on marine life and the people that depend on them are exacerbated further by climate change and other anthropogenic stressors[16].

The world is changing fast, and fisheries management, as presently practiced, largely lacks measures to ensure long-term ecological resilience and social equity[17,18] in not only sustainable, but also ethical fisheries[19]. We must transition towards viewing fishing as a privilege, rather than a right. Private fishers and fishing enterprises should exploit public fishery resources with attendant ethical responsibilities to limit environmental harm and promote societal benefit[20,21]. The slow pace of change towards more sustainable practices guarantees that marine fisheries will not, on their present trajectory, meet the urgency of global challenges. How then, can we adapt and future-proof fisheries in the face of long-term climate change and uncertainty?

Reform of marine fisheries is a central mechanism to improve ocean health, offering the opportunity to minimise the ecological impact of one of the largest and most widespread direct drivers of degradation[22–25]. Such reform will also amplify societal benefits from marine fisheries to human health, wellbeing and livelihoods[26–28]. Here we offer a vision for the future of ocean exploitation in which marine life and fisheries play a central role in the delivery of the SDGs.

The Vision: Marine fisheries should minimise the ecological impact of every fish caught and maximise its societal benefit

Marine fisheries are managed as social-ecological systems that recognise and respect relational values between humans and nature, support thriving oceans, and amplify the value of marine life to people and the planet. Their management recognises that fish and invertebrates are wild animals, the use of which entails reciprocal obligations to safeguard species and the wider environment. Fishing, when allowed, should be conducted in ways that sustain and recover ecological integrity and function, now and into the future, including measures to mitigate and adapt to climate change. Fishing minimises disruption to the natural world, in recognition of ocean health and the life support systems on which people and nature depend. Fishing provides for direct human consumption and food and nutrition security, is undertaken in ways that are socially just and equitable, promote human wellbeing and protect human rights, including the rights of Indigenous Peoples and small-scale fishers. Fisheries are managed within institutionally robust and transparent systems underpinned by effective and collaborative principles and participatory procedures that focus on community and economic viability. Detailed social-economic (e.g. access, allocation, employment, economic benefits, wellbeing) and environmental data (e.g. quota allocation, geolocation data) relating to commercial fisheries are made publicly available by national governments or intergovernmental regulatory bodies. Fisheries support decent jobs and livelihoods within environmental limits unsupported by harmful subsidies; internalise the economic, social, and environmental costs of fishing, including on ecosystem goods and services; and account for the full economic, social and cultural values of the fishery.

This view was deliberated and agreed upon by the co-authors, including ecologists, fisheries scientists, conservationists, social scientists, ethicists, economists, and food systems specialists. It challenges mainstream perception and practice, particularly for fisheries that employ methods with large environmental impacts, such as trawls and gillnets. To achieve systemic change to fishing practices and management, we must widen the present narrow objectives of traditional stock assessment to support diverse and healthy oceans and communities. Fishery managers, fishers, fishing companies and retailers must take responsibility to recover, protect and support marine life, and thereby sustain human wellbeing and their business interests. Such actions will improve resilience and promote adaptation to the growing risks posed by climate change.

In the following we present two core principles and a series of key actions to transform fisheries for the future (Fig. 1).

Principles for sustainable marine fisheries

Principle 1: Fisheries must minimise environmental harm, allow for the regeneration of marine life and habitats, and adapt to climate change

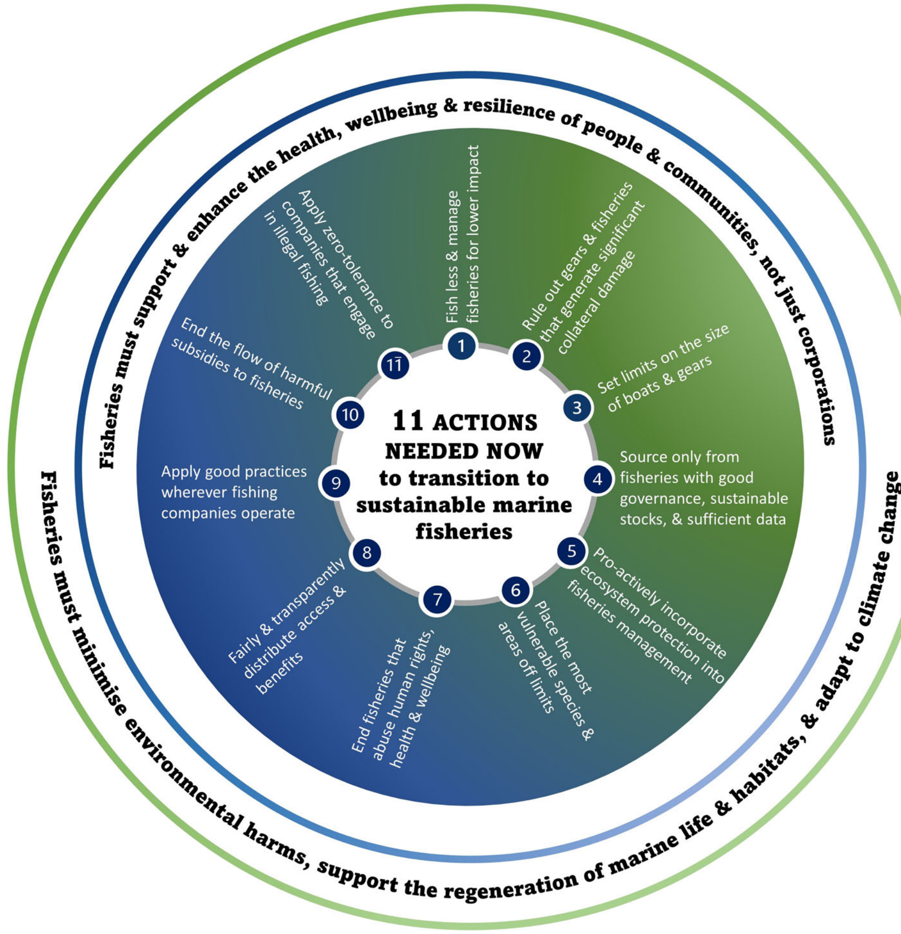
Marine life and habitats provide the natural capital basis of economic viability for fishing businesses. Against a global context of rapid environmental change, robust ecosystem functioning and resilience are foundational prerequisites for future fisheries sustainability and continued delivery of critical ecosystem services. These attributes are poorly served by the present focus on single species managed for maximum productivity. Managers must instead, by default, consider the wider ecosystem impacts of fishing and prioritise lower impact activities, coupled with measures that protect and promote ecosystem regeneration such as rebuilding depleted populations, creating fully protected marine protected areas, managing coastal development and restoring critical habitats. Healthy ecosystems function better than degraded ones and support services important to wider society, such as carbon sequestration and good water quality. Fisheries must also address their own contributions to the climate crisis through activities that are polluting (e.g. ghost gear and plastics) or carbon intensive (e.g. towed fishing gears) or destructive (e.g. disturbance of sediment carbon stores and slow growing habitat forming species).

Action 1: Fish less and manage fisheries for lower impact

Overfishing, by which we mean excessive take leading to population depletion below productive levels, has many causes. The most common are inadequate (or absent) regulation and enforcement, overcapacity, insufficient or inaccurate understanding of stock status, a misguided concentration on and flawed application of the concept of maximum sustainable yield, and insufficient attention to the difficulty of managing mixed species fisheries. The latter illustrates one of the most fundamental failings of conventional management: the impossibility of simultaneously fishing for all species at MSY[29,30]. Historically, species with life histories vulnerable even to low levels of fishing mortality (large size, slow growth, late maturation, long-lifespan, often from high trophic levels), have been progressively depleted and lost from mixed-species fisheries, leading to eventual industry dependence on a few resilient species, often from low trophic levels, such as prawns, scallops or flatfish[31,32]. While such fisheries may still be productive and profitable, the loss of other species leads to ecosystem simplification, impairing function and resilience[31,33]. Ecosystem functioning can also be compromised directly by removal of large volumes of planktivorous species (often called forage fish), which further negatively impacts higher trophic levels, including animals like seabirds and marine mammals that are not targets of fishing[34].

Governing fisheries to support higher biomass levels in the wild for both target and non-target species would rebuild ecosystem functioning and resilience, reduce management risk, increase room for error and buffer the effects of environmental fluctuations and change. Reducing exploitation rates, combined with shifting to more selective fishing gears, e.g. increasing mesh size[12], or to places with lower bycatch and less sensitive habitats, would produce higher population sizes, increase catch per unit effort, reduce fishing costs and cause less damage to habitats and non-target species[12,35]. Lower exploitation rates may also align more closely with maximum economic yield, the point of highest fisheries profitability[36]. Considerable disagreement exists surrounding the level of biomass to which a population has to fall relative to its unfished state before it is considered overexploited[37–39], with some estimates as low as 20%[40,41]. Reducing the abundance of marine life to low levels leaves very little room for uncertainty in estimates and error in management. Further management jeopardy arises because the unexploited biomass of a population on which reference points are based is often unknown or unobtainable and may become irrelevant under climate

Fig. 1 | Roadmap to fisheries reform. The two principles and 11 actions required to transition to sustainable marine fisheries.



change or some other environmental shock. Such reductions also amplify population variability in exploited species[42] as well as adverse ecosystem consequences from fishing[43].

Climate-adaptive fisheries management, particularly for exploited populations in need of rebuilding, requires fishing levels to be well below MSY[44]. Maintaining higher biomass could also enhance the ocean's ability to sequester carbon[45,46]. Adopting a biomass target of at least 60% of unfished levels (or appropriate population benchmark for naturally highly variable populations), would better secure ecosystem function and minimise risk[47,48]. In the absence of detailed stock assessment data, precautionary exploitation rates can be adopted based on local ecological knowledge and/or values from better monitored populations of the same or comparable species.

Action 2: Rule out gears and fisheries that generate significant collateral damage

Some fishing methods, such as fishing with explosives or poisons, are so destructive to habitats and ecosystems that they are already prohibited almost everywhere. Many currently allowed fishing methods, however, have significant destructive impacts that are not fully acknowledged or accepted for reasons of long use due to historic legacy and culture, resistance to change or lack of political will. Seabed-contacting mobile gears such as trawls, demersal seines and dredges fall into this category. They scrape, dig up and pulverise marine life in the process of catching fish and shellfish, such that regularly fished areas come to be dominated by shifting gravel, sands and mud, while marine animal forests such as mussel and oyster beds disappear[49,50]. While fishing is changing the functioning of the ocean carbon pump[51], a key process for mitigating climate change, bottom trawls, demersal seines and dredges have an additional specific impact by disrupting nature's carbon stores and causing re-release of greenhouse gases to ocean and, potentially atmosphere, although the magnitude of this release is still uncertain[52,53]. The lack of selectivity of mobile gears contributes to the problem of bycatch, and fishers' associated action of discarding, which causes waste and ecosystem disruption and threatens species with vulnerable life histories. Their continued use has contributed to the loss of other target fishery species, often long ago, and prevents the re-establishment of complex, flourishing ecosystems that support larger bodied fish and other wildlife and act as active carbon stores[54].

Other fishing methods result in large amounts of bycatch and ecosystem disruption, including gillnetting, surface longlining and the use of drifting fish aggregating devices (dFADs) in purse seine fisheries. The impacts vary with the specificity of the catch, for example purse seines targeting free-swimming single species schools result in cleaner catches than those targeting mixed schools associated with dFADs[55]. The waste associated with bycatch of undersized, unwanted or over-quota species has long been accepted as a necessary cost of fishing. Even sustainability standards that claim to promote low impact fishing have internalised this logic, permitting substantial bycatch, including seabirds and marine mammals, in eco-certified fisheries[56]. Such bycatch has been justified by recourse to the specious argument that it is insufficient to further endanger these species (or prevent their recovery). However, as this impact is often assessed at vessel or company-level, the full cumulative impact across all vessels in a given fishery is neither properly quantified nor considered.

Bycatch can be reduced by switching fishing gear, redesigning it or altering fishing practices (e.g. setting at a different time of day or avoiding places with high levels of bycatch species), although there are technological and economic limits to effectiveness[57]. Economic instruments can be used as in Namibia, for example, where fishers are required to land all bycatch and they are charged for any they land[58]. As interactions with fishing gear represent risk and danger for all species, even when not immediately fatal[59], the cumulative effect is often further decline, especially for rare and endangered species with low reproductive output[60]. Where fishing methods cannot be modified to sufficiently mitigate collateral damage, continued exploitation runs counter to sustainability principles and so should cease. For culturally important species, this raises the difficult issue of how to sustain cultural connections to vulnerable wildlife. Regardless of who it is that does the fishing, sustainable use is necessary to secure long-term rights and opportunities to natural resources. Cultural connections can be severed by traditional uses as well as by external operators using industrial methods.

Targeting species that can be caught more selectively with less damaging gear is important. Using static bottom gears such as longlines or handlines, for example, may reduce environmental harms[61] and mitigate unwanted catches[62]. Selective fisheries have the further advantage of simplifying stock assessments, thereby improving management advice and success of implementation.

Action 3: Set limits on the size of boats and gears

A gradual increase in fishing power over time—technological creep—is a near universal tendency of fisheries[63,64]. One manifestation is the growth in size of fishing vessels and gear deployed, and another is the increasing sophistication of the technologies they deploy. These trends also concentrate capital into fewer hands, sometimes creating monopolies, narrowing the distribution of economic and social benefits from fishing[65]. Many fisheries are highly carbon intensive, burning large quantities of fossil fuels often made cheaper by capacity-enhancing government subsidies. Among the worst performers in terms of fuel burned per tonne of landings are crustacean fisheries[66], fisheries that operate in distant waters, deploy heavy mobile gears like trawls, or target high value, low yield species like swordfish[67]; most of them are propped up by subsidies[68,69].

Economic considerations dictate that more powerful vessels concentrate fishing effort in places with high catch rates, but the scale of impacts increases with higher capacity. In combination, these attributes can lead to localised depletion of target and non-target species. Even where quotas are low relative to estimated overall stock size, such as with Antarctic krill, fishing sub-stock by sub-stock could exacerbate climate change ecosystem effects and accumulate over time into widespread decline[70,71].

Fleets made up of smaller boats can theoretically more easily match fishing effort to stock productivity, spread effort over wider areas, and avoid the serious impacts associated with higher-capacity gears. They are usually employment-intensive, sharing the economic rent of fishing among many fishers, and more generally participating in the economic, social lives, culture and wellbeing of coastal communities. Nonetheless, small-scale fisheries have problems of their own. There are many examples of overfishing, species loss and environmental damage in intensive artisanal fisheries, which are as important to resolve as issues affecting industrial fishing[72,73].

All fisheries use gears that can either be incidentally or, in some cases, purposefully lost during or after operation. Lost or discarded fishing gears often make up the largest category of plastic waste in the open sea[74]. Excluding gear deliberately disposed of by unscrupulous fishers when damaged or redundant, some gears are especially prone to loss such as gill nets, traps and drifting fish aggregating devices[75]. Gears lost while in use may continue to ghost-fish for weeks, months or even years, causing long term harm to marine life through pollution, entanglement and mortality. Mandatory labelling of fishing gear could encourage better stewardship as penalties could be levied on lost and retrieved gear.

Awareness of the pervasive impacts of ocean-borne plastic pollution has increased dramatically in recent years. An increasing number of recyclable gears are being tested and facilities to properly dispose of and recycle unwanted gear are becoming widespread. More generally, the fishing sector has to engage in the circular economy if it is to promote the sustainability of its products. The concept of fisheries sustainability must embrace the full impact of fishing on the environment and society, ruling out those fisheries that wilfully or carelessly contribute to overfishing, loss of livelihoods and wildlife and the burden of ocean pollution.

Action 4: Source only from fisheries with good governance, sustainable stocks, and sufficient data to assure sustainability

Over 90% of the world's marine species are transboundary[76], meaning fisheries often exploit populations shared by multiple countries[18]. Their management is therefore a collective responsibility undertaken through negotiation by government representatives. Such arrangements often lead to risk-prone decisions whereby quotas are set higher than is considered safe by scientific assessments and overfishing ensues, even in places like Europe where good scientific advice is often readily available[77,78]. The Eastern Atlantic bluefin tuna was a notorious victim of serial mismanagement but also illustrates how stocks can recover following more responsible decision making[79]. Similarly, the status of many other major tuna stocks has also improved in the last decade, in part the result of a turn toward (hypothetically) apolitical management frameworks known as harvest control rules[80]. In particular, small-island developing states in the Pacific have demonstrated how rights-based management may be effective even for transboundary, highly migratory fish[81], and these nations have asserted substantial governing power in an industry still dominated by foreign fishing companies[82]. In this part of the world, access to fishing in island state waters is based on an annual vessel effort limit, rather than a species quota or volume limit. As of 2021, all tuna populations in the Western and Central Pacific were considered biologically healthy, which is no small feat given half of the global tuna catch comes from here[83]. At the same time, some governments continue to act irresponsibly under international management frameworks and set excessive quotas in the short term that drive fisheries further into overfishing, as is the case, for example, for yellowfin tuna in the Indian Ocean[84]. Their actions are incompatible with sustainability.

A frequent response to overfishing is to diversify into catching other, less exploited species e.g ref. 85. The approach is encouraged by fisheries managers and directed subsidies, even in the absence of data on the new target species, the logic being that unfished or little-exploited populations are abundant enough not to need management control. The result, often repeated through history, is that the new species are soon overfished, and management action, when it is taken, is reactive, slow, insufficient and lacks transparency[86–88]. The plentiful examples of this problem demonstrate that sustainable fishing requires foreknowledge of stocks and pre-emptive regulation, especially in countries with industrial scale fleets and well-developed management capacity. Moreover, these unfished or little exploited populations can hold significant ecological roles that underpin other fisheries and key ecosystem services; without knowing better, the consequences of their exploitation could be far-reaching. A clear example is the growing exploitation interest towards the exceptionally high biomass of krill and mesopelagic fish which are key to the processes of carbon sequestration[89]. As the world looks for ways to promote nature-based solutions to the climate crisis[90], fishing for species that play a vital role in the carbon cycle makes no sense other than in narrow fishery economic terms. Before being opened, all fisheries should require long-term data sets from which sound scientific advice and clear management rules can be set to avoid repeated cycles of failure. A basic working principle is that the less one knows about a fish and its place in the ecosystem and world, the more precautionary fishery management should be[91,92].

Although small-scale fisheries often operate with less data and management capacity than industrial fisheries, sustainability can still be pursued by applying local ecological knowledge to better match fishing pressure to levels species can support, adopting measures to reduce the impact of fishing on habitats and bycatch species, and establishing participatory institutions to set and enforce local rules[93–96].

Action 5: Pro-actively incorporate ecosystem protection into fisheries management

Fisheries managers have rarely considered pro-active nature protection to be within their remit, even though protection of habitat and ecosystem integrity may be fundamental to the productivity of the species they manage, e.g. juvenile cod in the Gulf of Maine survive better in untrawled habitats[97]. Instead, managers assume that sufficient habitat of good enough quality exists, justifying their focus on target species in isolation. The narrowness of this view has likely contributed to many instances of species decline. If fisheries are to be sustainable in a wider sense, managers should not ignore their responsibility to protect habitats that are critical to life stages, maintain the functioning of ecosystems and sustain the wildlife they affect. This includes considering when, where and how fishing is conducted, and its broader impacts.

Spatial and temporal conservation measures must become an integral feature of modern fisheries management, to avoid adverse interactions with wildlife, protect habitats or promote their recovery, and direct fishing away from species or places of high ecological vulnerability or that are difficult to effectively monitor. Proactive nature protection measures safeguard and rebuild the natural capital on which fisheries are built. Examples of good practice include the temporal and spatial separation of lobster trap fisheries from feeding grounds of endangered right whales in Canada to prevent entanglement mortality[98], the use of networked no-take marine reserves to support artisanal reef fisheries in the Caribbean[99], and only allowing low impact static fishing methods in an area designed to allow recovery of seabed habitats impacted by mobile gears in Lyme Bay, UK[100].

Action 6: Place the most vulnerable species and areas off limits

Some species and places are inherently more vulnerable to fishing than others, such as fragile habitats fished using destructive gears, or the deep-sea relative to shallower waters. Some fish and shark species have life histories that are incompatible with even low levels of exploitation. The same is true for many sponges, corals and other sessile invertebrates[101]. Fishing deeper than 500 m with large-scale, industrialised gears should not be undertaken. The extreme conditions of darkness, high pressure and cold mean that productivity is low across much of the deep sea, and species there often possess highly vulnerable life histories meaning they are extremely slow to recover once depleted[102]. Many exploited deep-sea species are also particularly vulnerable to ocean warming, deoxygenation, acidification and changes in export production[103,104]. These features mean that, with few exceptions, the deep sea cannot support fisheries that are sufficiently productive to be economically viable at sustainable fishing rates[105].

Areas with near-natural structures, processes and functions are important reference sites that can help set conservation goals, guide recovery trajectories of impacted sites, inform adaptive management and contribute to rebuilding exploited fish stocks. Fishing in these areas should be avoided. A related concept is "freezing the fishing footprint" whereby the spatial extent of fishing activities is constrained. In the deep-sea, freezing the bottom fishing footprint prevents expansion into areas not yet disturbed, thereby creating reference sites that allow us to understand anthropogenic changes in the deep sea. A freezing of the deep-sea fishing footprint would also protect areas that likely contain cold-water corals, deep-sea sponges and other vulnerable biogenic habitats, e.g.[106]. Polar regions also lend themselves to freezing the footprint to prevent damaging expansion of fisheries into some of the most climate-change sensitive ecosystems in the world[107].

Principle 2: Fisheries must support and enhance the health, wellbeing and resilience of people and communities, not just corporations

Fisheries are an underperforming global asset. The difference between potential and actual net economic benefits from fisheries exceeds $ 80 billion per year, largely due to overexploitation[108]. Over the years, fisheries have become ever more technologically powerful. However, greater fishing power does not equate to greater production, with efficiencies often only slowing catch decline relative to the falling abundance of target species[63]. When functions of marine life that are difficult to value in monetary terms—including climate regulation, nutrient cycling, habitat provision, water quality, nutritional and cultural values[27,109]—are accounted for, marine life is dramatically undervalued.

Fisheries management has historically focused on economic output with limited consideration of social value and effects, e.g.[110,111]. Yet human labour, along with marine life, provides the basis for these outputs and all parties that work in the fisheries sector should benefit from it, including women, who represent a large fraction of fisheries workers, particularly in processing and trade, but have generally lower benefits and agency[5]. We take the view that marine life is a public asset, and its exploitation and management should work for the benefit of local communities and the public, with traditional users as rights-holders and citizens as central stakeholders and decision makers.

Action 7: End fisheries that abuse human rights, including those that threaten food security and livelihoods of people in the places they fish

There is now abundant evidence of widespread human rights abuses in fishing, including coercive practices, bonded, slave and child labour, and unsafe, indecent and unsanitary living and working conditions[112,113]. These practices represent cost-cutting subsidies to fisheries whose profitability is falling because of overfishing and/or rising costs[69]. Human rights abuses and infringement of safe labour practices are especially prevalent in distant water fisheries where boats are at sea for months or years at a time[112]. Fisheries found to be complicit in such human rights abuses should be boycotted and dismantled.

Distant water fisheries may also infringe on human rights, access rights, wellbeing, food security and livelihoods of local communities in the places they fish. For example, fisheries operating under access agreements or illegally in West Africa have led to loss of fishing opportunities for local, small-scale, nearshore fishing fleets[114]. In an era of food scarcity, fisheries should both contribute to global food security (where all people at all times have access to safe and nutritious foods[115]) and operate in ways that maintain or increase access to fish and seafood for the world's undernourished and impoverished coastal populations. But many do not, with sanctioned or illegal industrial fisheries undermining local catches and food security[114,116,117].

We need to refocus fisheries that do not contribute to food security towards production of premium products and supply of local markets with greater profit retention by small-scale actors including fishers, processors, traders and local communities, e.g.[118]. To reflect the true broader values of marine life, fish should be targeted for direct human consumption at local scales with short supply chains and not exploited as subsidised, cheap commodities to supply distant markets in rich countries, let alone for markets such as pet food, nutraceuticals, agri- or aquaculture, which may themselves have large environmental impacts. These sorts of supply chain dysfunctions and inefficiencies have led to global shortfalls of critical nutritional support for people[119].

Action 8: Create fisheries management systems that fairly and transparently distribute access and benefits

Decisions on access and allocation of fishing rights are contentious, often made behind closed doors and typically based on historical precedent[120]. This approach favours some groups over others, often fishery sectors with the most concentrated capital, greatest lobbying power and high environmental impact, e.g.[121–123]. To increase fairness and transparency in fisheries management systems, two changes are needed. First, fisheries need clear policy mandates to consider equity (and not just sustainability) in management, and established mechanisms to determine equitable allocation of access and benefits to various groups[124]. For example, the inherent rights of Indigenous Peoples and small-scale fishers to livelihoods and food should be considered before allocation to industrial fleets.

Second, representative, inclusive and participatory decision-making processes are needed to embed local rights holders and stakeholders. Cooperatives and other coalitions and networks of fishers and fish processors can support actors' participation in decision making and distribution of benefits[125]. To enhance social benefits from fishing, wider recognition and representation of rights-holders (e.g. Indigenous Peoples, small-scale fishers, traditional resource users) and stakeholder groups is necessary, including civil society. Indeed, non-governmental stakeholders, such as environmental NGOs and Indigenous groups, are increasingly valued and active participants in decision-making processes[126]. At the same time, depending on the tactics and resources used to support the missions of these groups (e.g. private foundation funding), their motives may also be viewed as opaque, especially by fisheries managers in low-income countries[127]. To alleviate these concerns, government-associated fisheries managers as well as stakeholders from the private sector should be mandated to adequately and transparently consider, evaluate and report decisions on access and benefits to achieve the diverse objectives of the UN SDGs.

Action 9: Apply good practices wherever fishing companies operate

Multinational companies are often criticised for applying different standards across their global supply chains, for example employing child labour or exposing people to dangerous working conditions in less regulated jurisdictions, e.g.[112,113,128,129]. Allied to this, companies often operate under flags of convenience, benefiting from less rigorous or non-existent regulatory regimes[130]. Reduced operating costs represent the upside for the businesses involved. However, just because a practice is legal does not make it ethical or morally acceptable. Risk of illegal, unreported and unregulated fishing and labour abuses is higher when a fishing vessel operates under a flag state with poor control over corruption or is largely owned by countries other than the flag state[131].

A more inclusive definition of sustainability rejects that avoidable human and environmental costs are justified in the pursuit of profit. Responsible companies apply good practices wherever they operate, do not illegally fish, and do not hide behind flags of convenience. Responsible companies also engage in corporate social responsibility practices, such as benefit sharing and local hiring, and move beyond a focus on no harm to human rights, towards promoting wellbeing in local populations[132].

Action 10: End the flow of harmful subsidies to fisheries

Harmful subsidies are anathema to sustainable, low impact fishing. They are defined as capacity-enhancing subsidies, which increase fishing power by artificially inflating private fishing company profits[133]. They include, for example, tax breaks on fuel, discounted fishing gears, support for vessel construction costs[134] or payments for access to foreign waters[135]. Harmful subsidies have long been recognised to contribute to overfishing and management failure[134] and, more recently, greenhouse gas emissions[136]. Globally, public entities provided capacity-enhancing subsidies of an estimated $ 22.2 billion in 2018[134]. Most of this (>80%) went to large-scale industrialised fishing activities thus conferring an inequitable competitive advantage over small-scale fisheries[137]. Using taxpayers' money to fund capacity-enhancing subsidies also increases risk of labour abuses[138], fosters ecosystem degradation and represents extremely poor social investment and value for money. The provision of harmful subsidies also runs counter to legal recognition of everyone's right to a "safe, clean, healthy and sustainable environment"[139].

After decades of negotiation, the World Trade Organisation (WTO) agreed in 2022 to implement a ban on capacity-enhancing subsidies, albeit only for fisheries engaged in illegal, unreported or unregulated (IUU) fishing, those targeting overfished stocks, and fisheries in areas of the high seas outside the competence of a regional fisheries management organisation/authority[140]. The ban will only come into force when at least two-thirds of WTO members formally accept it, and if they do so within 4 years (as of July 2024, 82 of 164 WTO members had accepted). However, many subsidies that contribute to overcapacity and overfishing were excluded from the final agreement due to lack of consensus[141], such as subsidies for equipment/machinery, fuel, ice, access to foreign waters, bait, personnel, social charges or insurance.

Action 11: Apply zero-tolerance to companies that engage in illegal fishing

Illegal fishing is not only wrong in law, it undermines both fisheries management and human rights and retailers should adopt a zero-tolerance approach to it in procurement practices. It leads to uncertain estimates of target species removals and population sizes making it harder to allocate access or prevent overexploitation. IUU fishing has been linked to transnational organised crime, modern slavery and labour abuses, undermining of food security and loss of government revenue[113,131,138,142–144]. Globally, illegal fishing is estimated to land between 8 and 14 million metric tons with gross revenues of $ 9–17 billion[142]. Illegal fisheries are fostered by weak deterrence, with typically low fines that are seen by some as worthwhile business costs, especially where catching power is falling and costs rising due to poor management. Poor governance and lenient treatment of fisheries violations encourages repeat offending, e.g.[145–147], with those found guilty often still receiving government subsidies, or certifications of sustainability. Fishing vessels that are more likely to engage in illegal fishing and labour abuses more often use ports in countries that have not ratified the Port State Measures Agreement due to their less rigorous procedures[131]. Therefore, companies associated with IUU fishing and vessels that land fish in ports not regulated by the Port State Measures Agreement, should be avoided.

Implementation

The biggest challenge in achieving lasting fisheries sustainability lies in the implementation of the actions we outline. Fisheries are as multifaceted and complex as human societies and what works in one context may not in another. Further work should look to integrate our actions into specific social-ecological contexts to develop locally appropriate sustainability plans with all relevant stakeholders. That said, nearly all the actions we describe have been demonstrated to work somewhere. For example, Australia's supertrawler ban of 2014[148], its fishing of northern prawns at MEY rather than MSY[149], and the UK's closure of sand eel fishing in 2023 to protect seabirds[150]. In most cases, a combination of complementary strategies will be required to achieve the package of actions required for full sustainability[151].

Success is most likely, where two elements come together: good governance and realigned incentives[152,153]. On the incentives side, the most systemic shift towards better fisheries practice will come from the withdrawal of harmful subsidies, especially tax breaks on fuel. Many of the most destructive fisheries will simply become uneconomic when this prop is withdrawn. We are not yet there, but progress continues at the WTO, and within countries[154]. Subsidies can be repurposed to incentivise good practice too, such as compensating fishers for adopting less impactful gears[155] or for supporting protected areas[99]. Wholesalers and retailers can proactively incentivise change, offering market access or better prices for fish caught from fisheries that meet more stringent sustainability standards. The framework we outline in this paper offers them a blueprint by which to judge performance.

As the twin climate and biodiversity crises demand more urgent action, realigning of incentives will happen to control harm by fisheries. Fisheries decision making has typically been inward looking, mindless of negative consequences for environment, society or human wellbeing. Subsidies to fleets of the Global North under distant water access agreements, for example, conflict with efforts to reduce malnutrition or poverty in the Global South[114]. Environmental quality, conservation and climate mitigation targets are undermined by destructive fishing. Better fisheries governance is therefore imperative to broader societal goals, as expressed in the SDGs. Meeting those targets requires a shift to more integrated decision making and restructuring of incentives to resolve policy conflicts and achieve multi-dimensional objectives.

Governance reform often only happens in response to shocks, like stock collapses, or external pressure. Environmental NGOs have become a potent force driving fisheries reform. After coordinated campaigns by eNGOs, the EU banned electric pulse trawling and bottom trawling below 800 m deep, and measures were taken to recover Atlantic bluefin tuna. These campaigns draw upon diminishing public tolerance for destructive behaviour by private industry[156], which allied with increasing consolidation of fishing companies into global giants, makes such pressures easier to leverage with potential for broader benefits when successful[157]. Good governance may be harder in places lacking strong institutions. However, successes have been achieved through co-management between government and local communities[158]. For example, government support for customary laws and local leadership in Indonesia has brought destructive fishing under control in Raja Ampat and fostered support for lower impact methods and marine protected areas[159].

Conclusions

How future fisheries are managed is important for sustainable development and society, but it is also important because marine life is a public good that should be valued and used for the benefit of society and nature, not exploited solely for private profit[160]. Given the urgency of addressing societal challenges, we must go further and faster to prepare for future risks and mitigate the already apparent effects of rapid global change and human population growth. We need to urgently scale up efforts to transform fisheries to protect marine life and support society. It is the shared responsibility of policy makers, fisheries managers, fishers and retailers to minimise the environmental impact of fishing and amplify its social benefits, of which profit is only one element. This means making better choices regarding the why, what, how, and where of capture fisheries. Importantly, examples of successful conservation of marine spaces and species do exist, often where human capacity and resources would appear limited[132,161–163]. In the context of fisheries, work aimed at improving our understanding of key drivers of effective governance frameworks and remediation activities should continue in earnest given the multitude of diverse challenges that persist in both large and small-scale operations around the world.

We propose that all fisheries adopt and report on the two connected principles and associated actions elucidated above, to better serve humankind and nature and support progress towards multiple SDGs. Adopting our priority actions will integrate nature conservation into management, incorporate local ecological knowledge in decision making, improve size-based and species-based gear selectivity, end the use of destructive gears, prioritise access and support to lower impact gears and fisheries with more just distribution of benefits, remove capacity-enhancing subsidies and reduce fishing effort and overcapacity.

Consumers increasingly demand that fisheries are conscious of biodiversity, people and climate. Using their reach to accelerate change, fisheries need to adopt greener, more equitable practices. For businesses this means measuring not only carbon but their overall ecological footprint, improving the fuel efficiency of vessels, auditing supply chains, reducing waste, engaging in circular economy, converting to non-destructive fishing methods, applying high standards wherever they fish, avoiding use of flags of convenience or taking advantage of weaker local rules.

Strategies to build resilience as well as policy and management considerations, potential trade-offs, and social and economic contexts differ among fisheries, communities and the countries within which they operate. Industrialised fisheries are often poorly performing businesses that may have appalling environmental and social records. By adopting the reforms needed to reduce harm, widen access to and redistribute benefits, the environmental gains, long-term profits and overall societal benefits will, we argue, far outweigh losses. In fact, if wisely managed as argued for in this contribution, humanity can expect to receive benefits forever, achieving what has been described as 'infinity fish'[160]. Given a background of intensifying climate change, sustainable fisheries management must also be climate-adaptative and contribute positively to carbon mitigation.

For artisanal and subsistence fisheries, which have a more direct link to local communities through local and domestic fish consumption, the challenge will be to design interventions that support economic development but that positively address social and environmental impacts. However, the gains to fish stocks and habitats achieved by reducing the impacts of industrial fishing, will provide opportunities to increase social benefits, reduce environmental costs and increase resilience of these fisheries.

The above principles and actions redefine the notion of sustainable fisheries to balance environmental, social, economic and institutional dimensions to rebuild marine life, restore and regenerate ecosystems, support climate change mitigation and adaptation, promote system resilience to shocks and opportunities, and improve human wellbeing. They provide an enhanced basis to re-evaluate sustainability of existing fisheries and to develop policies, procurement guidelines, regulations and incentives to guide system transformation, to the benefit of humankind and the ocean.

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Competing interests
The authors declare no competing interests.

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