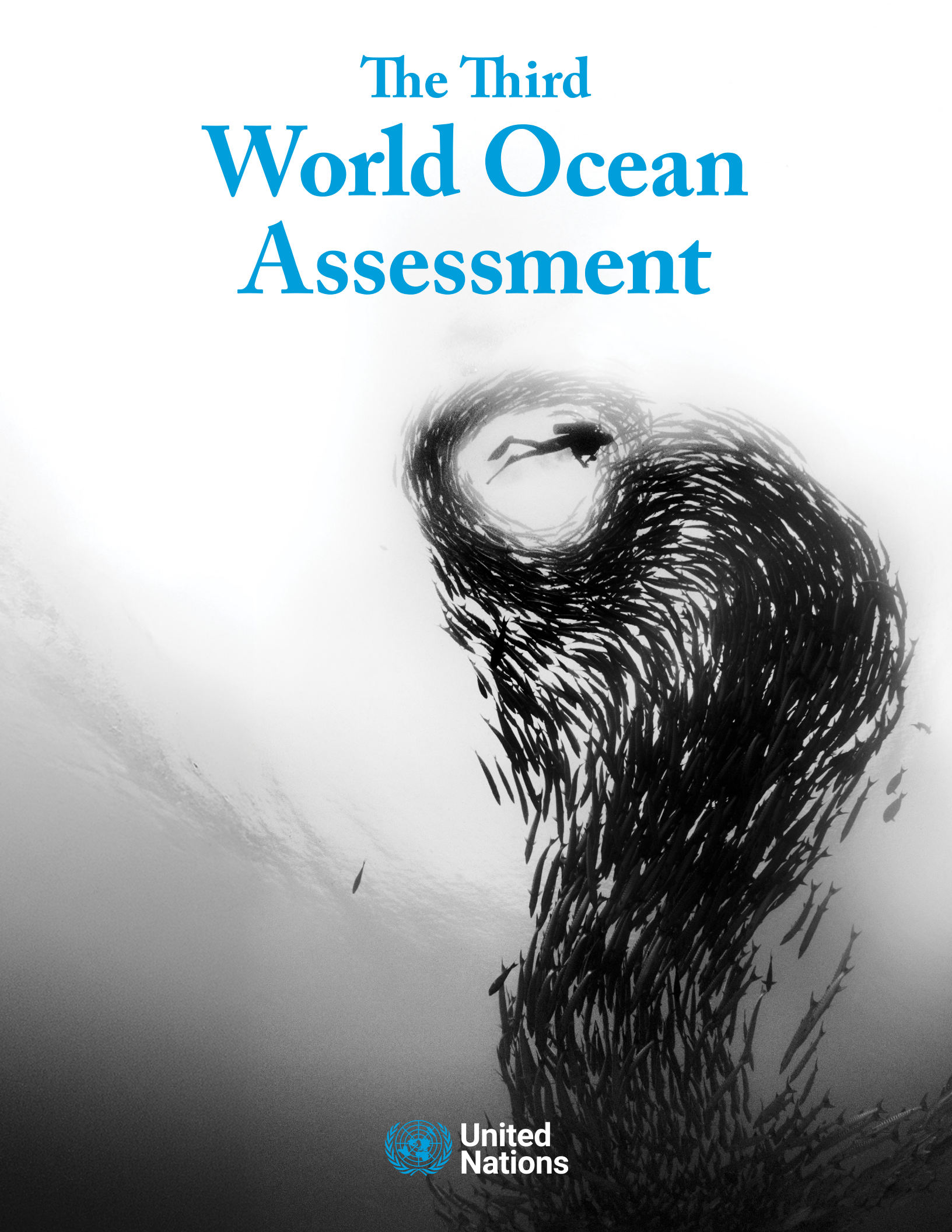
The Third World Ocean Assessment



United Nations

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WORLD OCEAN ASSESSMENT III

United Nations

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Chapter 2
Recreational fishing

Key points

- Marine recreational fishing is a widely practised activity with substantial economic and ecological impacts, especially on coastal ecosystems. Marine recreational fisheries generate billions of dollars annually, particularly in developed nations. The fact that many marine recreational fisheries are not formally recognized creates governance challenges for sustainability.
- Effective management requires addressing data gaps for data-driven management, including integration of socioeconomic factors, fostering stakeholder collaboration and implementing equity-focused management frameworks and integrated governance, and promoting stewardship and compliance through education.

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1. Introduction

Recreational fishing, defined as fishing of aquatic animals (mainly fish) that do not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets (Food and Agriculture Organization of the United Nations (FAO), 2012), takes place in about three quarters of the world's exclusive economic zones (EEZs) (Mora and others, 2009). Globally, an estimated 300 million people participate in recreational fishing each year, generating at least $47 billion in expenditure (Arlinghaus and others, 2019; Cisneros-Montemayor and Sumaila, 2010). Many recreational fishers engage in both freshwater and marine recreational fisheries, which makes it challenging to estimate the number of marine recreational fishers. One estimate suggests that 121 million people worldwide participate in marine-based recreational fishing (Cisneros-Montemayor and Sumaila, 2010).

Rates of participation in recreational fishing in countries with reliable statistics average around 10%, translating to approximately 140 million anglers in North America, Europe and Oceania alone (Arlinghaus and others, 2015). However, participation rates do vary significantly by country. More than 40% of Norwegians (Arlinghaus and others, 2015) and 21% of Australians (Moore and others, 2023) engage in recreational fishing, primarily marine fishing. Other countries, such as Brazil, report lower participation rates (about 1%) (Freire and others, 2016), but these lower numbers are likely to be influenced by data gaps on recreational fisheries (FAO, 2012). Recreational fishing is the fastest-growing fishing subsector in China (Ding and others, 2021). Similar trends have been observed in other developing countries in Asia and Africa (Kadagi and Wambiji, 2021), brought about by changing social norms, economic development and tourism (Coleman and others, 2004; Cooke and Cowx, 2004).

The focus of the present chapter is on marine rather than freshwater recreational fisheries. Integrating marine recreational fisheries into marine fisheries conservation and management is important owing to the ecological impacts of excessive recreational harvest (Altieri and others, 2012; Lewin and others, 2006, 2019), but also in view of the significant social and economic benefits that such fisheries bring to communities and participants (Hyder and others, 2018). Marine recreational fisheries support employment in retail, boating, tourism and related sectors, and offer public health benefits by encouraging outdoor activities and supporting nutritional security (Cooke and others, 2018; Henry and Lyle, 2003). In some coastal areas, the economic value of recreational fisheries exceeds that of small-scale commercial fisheries (Strehlow and others, 2023). The value of recreational fisheries for individual participants, however, lies in psychosocial benefits, relaxation and access to self-caught fish (Parkkila and others, 2010) . Furthermore, marine recreational fisheries foster awareness about conservation issues, strengthening the connection between fishers and marine ecosystems (Barnett and others, 2016) and promoting broader stewardship efforts (Shephard and others, 2023, 2024). The socioeconomic and ecological significance of recreational fishing underscores the need for sustainable and scientifically informed management practices in marine environments that take into account the needs, impacts and socioeconomic importance of marine recreational fisheries (Cowx and others, 2010; Hyder and others, 2018, 2020).

Certain marine and coastal aquatic species are exploited either solely by recreational fishers or by both recreational fishers and commercial and customary fisheries (Arlinghaus and others, 2019, 2023; Hyder and others, 2018; Ihde and others, 2011; Mora and others, 2009). Given the large number of people engaged in marine recreational fisheries, the impacts are diverse and include: (a) potentially high harvest rates of fish and other animals, which can reduce population abundance; (b) selective removal of specific species, sizes and genotypes, leading to truncated age and size structures and potential trophic cascades that may affect ecosystem stability, ecological interactions, genetic diversity and adaptive potential; (c) habitat modification and disturbance as a result of trampling, boating, anchoring and bait collection; (d) pollution from lost or discarded fishing gear; and (e) the introduction of invasive species via bait transfer (Lewin and others, 2006, 2019). As these impacts vary by location and fishery, local evidence is necessary to better understand the relative importance and consequences of these pressures.

Recreational fisheries are by no means the only source of impact on coastal fish populations. In fact, although comprehensive global assessments are limited, evidence suggests that marine fish populations are generally more heavily affected by industrial commercial fisheries than by recreational fisheries. However, the populations of specific coastal species that are easily targeted may be predominantly harvested by recreational fishers

(Altieri and others, 2012; Kleiven and others, 2016). In some cases, such as in Australia and the United States of America, recreational fisheries contribute up to 100% of the harvest for specific coastal fish populations (Coleman and others, 2004; Tracey and Stark, 2024).

As the economic situation improves in many countries, motivations for recreational fishing are shifting from food provision to leisure and experience (Kleiven and others, 2020). These non-catch benefits (e.g. enjoying nature) mean that recreational fishing effort often remains steady despite declining fish populations, unlike fishing effort in commercial fisheries, which often correlates with stock levels and expected gains (Kleiven and others, 2020; Post and others, 2002). Recreational fishing effort surged in many regions during the coronavirus disease (COVID-19) pandemic, though the long-term sustainability of this increase is uncertain (Audzijonyte and others, 2023; Britton and others, 2023; Kaz and others, 2024).

Despite the popularity of marine recreational fishing, reporting marine recreational catch is not required in most countries, with the exception of certain specific species or regions (Coleman and others, 2004). In Brazil, tournament catches must be reported, but compliance remains low. The European Union recently mandated marine recreational catch reporting, though implementation across member States will take years. Consequently, estimates of total marine recreational catches and harvests are highly uncertain. The global Sea Around Us project (Freire and others, 2020) estimates global marine recreational landings at over 900,000 tons in 2014. Independent estimates suggest annual removals of around 200,000 to 300,000 tons in the United States (Andrews and others, 2018; Cooke and Cowx, 2004), 350,000 tons in the European Union (Hyder and others, 2018), and some 25,000 to 30,000 tons in Australia (Henry and Lyle, 2003) and New Zealand (Southwick and others, 2018). The actual catch from recreational fishing is likely to be much higher as some fish are caught and released (Coggins and others, 2007), and the impacts of post-release stress and mortality are likely a significant cause of unaccounted mortality in some fisheries (Cooke and Suski, 2005).

Catch and release is widely practised: it is estimated that, worldwide, 60% of recreational catches are released (Cooke and Cowx, 2004), although estimates range widely based on country, fishery and species (Ferter and others, 2013; Lennox and others, 2017). Fishers catch and release either in order to comply with management regulations, such as bag or size limits, or simply by choice, releasing a fish that could be legally harvested (Ferter and others, 2013). The impact of catch-and-release practices is complex, and post-release mortality varies across species depending on factors such as water depth, gear used, fisher behaviour, fish handling times, water temperatures and species biology (Brownscombe and others, 2017). In addition to direct post-release mortality and barotrauma injuries — which are particularly relevant in deep marine environments — other potential negative impacts of catch and release include hook-related injuries, effects on growth and reproduction, increased predation risk after release, and reduced reproductive success if fish are caught and released during reproductive activities (Arlinghaus and others, 2007). In certain contexts, such as fishing at great depths or in areas with high predation pressure, post-release mortality rates can be extremely high, raising ethical concerns about whether releasing fish could be considered "wasting" fish (Coggins and others, 2007).

As reliance on fishing for food diminishes in more developed nations as a result of changes in the management of recreational fisheries and social norms, release rates are likely to further rise in cultures in which the practice is perceived as a conservation measure that reduces mortality. Alternatively, release rates may decrease where catch and release is viewed as an unethical practice, akin to playing with animals without a purpose — a perspective held in certain individuals and cultures, as in Germany and Switzerland (Arlinghaus and others, 2012). In these countries, only fishing for food is considered morally acceptable, and indeed the primary motivation in many countries for catching fish is for food (e.g. Atlantic cod, *Gadus morhua*) (Bronnmann and others, 2023).

Beyond the direct impacts of harvesting and catch-and-release fishing, recreational fishers are often highly selective, targeting the largest specimens and predatory fish (Flink and others, 2024; Lewin and others, 2006). They also disproportionately remove more active and bolder fish (Biro and Post, 2008; Klefoth and others, 2017; Sbragaglia and others, 2024), which may have higher reproductive success and adaptive potential (Sutter and others, 2012). The removal of predatory species based on size and other traits can affect ecosystem trophic structure by changing natural species composition and reducing predatory control (Lewin and others, 2019).

2. Pressures

Over the past decade, changes in the impacts of marine recreational fisheries on ecosystems and fish populations have been driven primarily by: (a) a growing human population, especially in coastal areas (about 15% of the global population currently lives within 10 km of a coast) (Cosby and others, 2024); (b) rapid advances in gear and technology, allowing recreational fishers to detect and target specific species, gain access to previously unreachable areas and use increasingly effective lures and baits (Cooke and others, 2021); and (c) the rise in communication technologies, which facilitate rapid information exchange and are shifting societal norms, with both positive and negative effects on marine ecosystems (Cooke and others, 2021). While the total global estimated marine recreational harvest constitutes only about 1% of total commercial landings, recreational removals are generally concentrated, and its impacts most intense, in narrow bands of coastal areas (Coleman and others, 2004). Given the potential environmental impact of recreational fisheries, sustainability is a growing concern (Lewin and others, 2006, 2019). Sustainable practices involve not only ecological but also social and governance-related issues (Coleman and others, 2004; Cooke and Cowx, 2004; Grati and others, 2024).

The cumulative impacts of recreational fishers on marine habitats extend beyond fish harvest and include disturbances from boating, anchoring and shore-based activities. In Australia, for example, there are 900,000 recreational vessels, which is 50 times the number of artisanal and industrial vessels combined.[1] That level of boat ownership is not uncommon in developed countries. Boating activity, including anchor deployment and propellor wash, can locally impact habitats such as reef systems and seagrass beds, though global impacts remain relatively low (Lewin and others, 2019). Shore-based fishing and land-based bait collection can degrade the fragile habitats in which these activities are performed intensely (Lewin and others, 2006).

As is the case for all fisheries, some fishing gear is lost during marine recreational fishing, contributing to the abandoned, lost or otherwise discarded fishing gear problem (Watson and others, 2022a). Overall, the impacts of abandoned, lost or otherwise discarded fishing gear from marine recreational fisheries are considered relatively small when compared with commercial fishing activities as the gear itself is generally small and is not routinely lost (Bornt and others, 2023; Lewin and others, 2019).

As recreational fishing remains largely unreported and, in many cases, unregulated, it is often overlooked as a component of global fisheries (Arlinghaus and others, 2019). Common regulations include licensing, gear restrictions, spatial and temporal closures, daily catch limits and size limits. However, total effort and harvest are rarely restricted at the population level, and less popular species often have no size or catch limits. Compliance monitoring is often challenging, especially in remote areas or where recreational fishing effort is relatively low and dispersed, and many recreational fishers may not even be aware of regulatory requirements (Freire and others, 2012; Ryan and others, 2025; Venerus and Cedrola, 2017).

To summarize, key sustainability challenges in recreational fisheries include declines in biomass, truncations in fish size and age through harvest, and intensified local fishing efforts that can threaten biodiversity and fish populations and, in extreme cases, lead to trophic cascades (Altieri and others, 2012). Other challenges include the introduction of non-native species via recreational gear, the lack of consideration of recreational fisheries in marine spatial planning and fisheries management (Arlinghaus and others, 2023; Hyder and others, 2018; Ihde and others, 2011) and the difficulties of obtaining data required for sustainable management, such as those on recreational catch and discards (Cowx and others, 2010; Garibaldi, 2012; Karachle and others, 2020).

Perhaps one of the greatest overarching pressures on marine recreational fisheries that incorporates all of the factors identified above is the shared utilization of coastal regions and the ecosystems and resources that they encompass (Barbier and others, 2011; Navarro and others, 2022; Noble and others, 2019). This theme is consistent with the findings of several other chapters in the present *Assessment* and is explored further from a marine recreational fisheries perspective below, under the heading “sustainability pathways”.

[1] See https://bia.org.au/wp-content/uploads/State-of-Industry-Report-2024.pdf.

3. Socioeconomic considerations

Recreational fishing generates extensive social and economic benefits on multiple scales, from individual participants to communities, regions and nations (Parkkila and others, 2010). The concept of value is interpreted variably across disciplines, with Parkkila and others (2010) identifying the psychological, social and economic impacts of fishing, distinguishing between individual benefits (e.g. angler satisfaction or health) and broader economic effects (e.g. regional tourism expenditure). In microeconomic terms, the value of recreational fishing for individuals is often measured as willingness to pay to participate. Meta-analyses have revealed high individual willingness to pay in marine recreational fisheries, with thousands of dollars generated from a single charter trip (Johnston and others, 2006; Whitehead and others, 2013). Recent estimates suggest a total willingness to pay of $11.4 billion for European recreational fisheries alone (Gren and Marbuah, 2024). While willingness to pay can quantify some of these benefits, many psychological and social values are difficult to measure (Parkkila and others, 2010). Recreational fishers often engage in environmental stewardship (e.g. coastal clean-ups or habitat restoration), participate in management councils or donate tournament catches to charity. Valuing these societal contributions is not straightforward and is rarely done quantitatively.

A macroeconomic perspective focuses on the economic impact, specifically jobs created through recreational fisher expenditures, which are particularly valuable in coastal regions reliant on tourism. In Europe, marine recreational fisheries contribute €10.5 billion and 100,000 jobs, while in the United States, they support $138 billion in sales and 692,000 jobs (Hyder and others, 2018; National Marine Fisheries Service (NMFS), 2024). In Brazil, between 2011 and 2014, marine recreational fishers spent $524 million annually (Freire and Sumaila, 2019). These benefits support local and national economies, especially in rural and coastal areas, through job creation in boat and vehicle manufacturing, fishing tackle, outfitting and tourism industries. The magnitude of the financial benefits generated by recreational fishers can be significant, at times exceeding commercial fishing revenues for certain stocks (Oinonen and others, 2016; Scheufele and Pascoe, 2022; Strehlow and others, 2023).

However, comparisons between the contributions of recreational and commercial fisheries are difficult and require examining producer and consumer surplus rather than changes in macroeconomic variables (Scheufele and Pascoe, 2022). Much of the value of recreational fishing is classified as non-market as it is derived from the fishing experience itself, which is not reflected in market prices. Some of this value can be estimated or inferred through travel cost methods, contingent valuation or choice experiments. Long-standing and well-managed recreational fisheries help to preserve local cultures and traditions, support regional economies and support fishers transitioning from non-profitable commercial fisheries. At the same time, in some countries, recreational fisheries that attract tourist trade often face the prospect of foreign ownership, limiting local economic benefits to local communities (Potts and others, 2022).

For effective consideration of socioeconomics in policy on recreational fisheries, studies must consider how the recreational fishery provides economic benefits to communities where the activity is taking place (Potts and others, 2020). Traditionally, particularly in underdeveloped communities, most of the money spent by recreational fishers is not retained in the local economy. For example, Butler and others (2020) found that the local community retained less than 10% of the money that foreign recreational fishing tourists spent at a lodge in Angola. When this economic leakage was considered, it was found that the community obtained greater economic benefits if the fish was captured in the artisanal fishery. Similarly, Potts and others (2022) found that less than 10% of the money generated by recreational fishing was retained in low-income households in a South African recreational fishery. They suggested that a whole-of-government approach, which included the identification of hotspots for recreational fisheries tourism, the development of local education and skills, and investment in appropriate infrastructure through public-private partnerships, would be necessary to realize the potential of recreational fisheries to drive social development.

In addition to having limited economic benefits, tourist-based recreational fishing ventures can clash with local communities and small-scale and subsistence fisheries. In such scenarios it is important to consider the cultural, spiritual, economic and nutritional benefits of fisheries to local communities. In the case of Indigenous Peoples that engage in ceremonial or subsistence fishing, they must be viewed as rights holders with priority access to fisheries resources. The boundary between recreational and subsistence fishing can, however, be blurred (Nyboer

and others, 2022). Given the need to manage fisheries in a cohesive and comprehensive manner, it is essential that fisheries planning extend across sectors and consider not just fish populations and fishery dynamics but also cultural traditions and values, as well as sovereign rights to fish, involving fishers as active participants in decision-making (e.g. via co-management) (Arlinghaus and others, 2016; Cooke and others, 2023).

From a demographic perspective, recreational fishing is often male-dominated and of limited ethnic diversity, and generally has a higher proportion of older participants (Arlinghaus and others, 2021; Moore and others, 2023). The reasons for that skew are unclear and may include barriers related to socialization (Arlinghaus, 2024). Some recreational fisheries tend to be limited to those with high disposable income given high entry costs, such as the purchase of a boat and the purchase of fuel, and fisheries targeting large pelagic species, such as tuna or billfish, are one of the most expensive ventures. By contrast, lower-cost shore-based coastal fisheries attract participants from lower socioeconomic backgrounds who often rely on catch to supplement protein consumption (Cooke and others, 2018). Disability inclusion in marine recreational fisheries is less understood (Lindsay and others, 2022). There are marine recreational fishery programmes that support recovery from mental health issues and rehabilitation of offenders (Bennett and others, 2017). Ensuring equitable participation remains an opportunity to enhance diversity within the sector.

There is increasing recognition that recreational fisheries must be studied and managed as coupled socioecological systems (Arlinghaus and others, 2017; Kleisner and others, 2022; Solomon and others, 2020). For example, increasing societal concerns about animal welfare resulted in bans on voluntary catch-and-release practices in Germany and Switzerland. Recreational fishing must therefore foster its social licence by meeting ethical standards, respecting animal welfare, adopting high sustainability and welfare standards (Brownscombe and others, 2017) and demonstrating environmental responsibility (Arlinghaus and others, 2012, 2021).

Community concerns about recreational fishing may also arise from conflicts with other water users, such as swimmers at a beach, for instance when vessel captains do not adhere to no wake zones. Increased marine traffic and the overall utilization of ocean space are matters of growing concern that must be resolved with adequate spatial planning. Marine spatial planning is a process aimed at reducing conflict and managing ocean space in line with economic, social and environmental objectives. Zoning frameworks support this goal in some instances, such as the Great Barrier Reef Marine Park in Australia, where zonation is aimed at balancing recreational fishing with commercial activities, diving and research (Stephenson and others, 2023). Such zonation can mitigate some user conflicts but may restrict recreational fisher access, creating further conflict. This problem is most acute in nearshore environments, where there are various forms of recreation, vessel traffic and coastal development. Managing relationships with other users and addressing conflicts over shared water resources will be critical as coastal populations grow and coastal development increases (Ramadhan and others, 2022).

Figure I
A young recreational fisher in Australia



Source: Sean Tracey.

4. Sector-relevant governance

The recreational fishing sector's lack of formal recognition is a fundamental concern in fisheries resource governance (Arlinghaus and others, 2019; Grati and others, 2024; Hyder and others, 2020; Potts and others, 2020), contributing to overexploitation (Cooke and Cowx, 2004), conflicts with commercial and subsistence fishers (Gómez and others, 2021; Kadagi and others, 2021; Said and others, 2018) and reduced societal benefits from recreational fisheries (Grati and others, 2024). Despite its importance, only about two thirds of countries mention marine recreational fishing in primary fisheries legislation (Potts and others, 2020). Barriers to recognition include limited data on recreational fishing participation, catches, biological impacts and socioeconomic importance, as well as a historical bias favouring commercial fisheries (e.g. the European Union Common Fisheries Policy) (Grati and others, 2024). Where economic value and impact data exist, efforts to compare these metrics with other fisheries often face stakeholder resistance, complicating resource allocation. Even among countries that recognize recreational fisheries, definitions are often unclear or insufficient for legal and management purposes, making it difficult to distinguish between recreational and other small-scale fisheries. Recreational fishers range from affluent, specialized touristic fishers to poorer individuals dependent on fishing for basic nutrition (Cooke and others, 2018; Nyboer and others, 2022), underscoring the need for locally adapted definitions. In some cases, there is a blurred boundary between "recreational" and "traditional" fishers given that the former could represent remnants of what was formerly a commercial small-scale sector. A case in point is the Mediterranean, where a number of individuals from fishing families have resorted to recreational licences to maintain the family tradition because fishing capacity regulations were pushing small enterprises out of business (Said and others, 2018).

The lack of data on marine recreational catch and effort and the misalignment of existing data with monitoring and reporting scales across jurisdictions make it difficult to integrate recreational fisheries data into stock assessments and management frameworks (International Council for the Exploration of the Sea (ICES), 2024). There are, however, some emerging examples of integration at various scales (Carruthers and others, 2014; Punt and others, 2020). This challenge is particularly pressing for those stocks for which recreational fishing is a significant cause of mortality (Griffiths and Fay, 2015).

Assessment methods are chosen on the basis of data availability, from data-poor (catch, effort, length) to data-rich (catch, abundance index, age/length composition) (Hoyle and others, 2024; Kokkalis and others, 2024; Rudd and others, 2021). Methods for the integration of data on marine recreational fisheries include catch-only models for species such as Baltic northern pike (*Esox lucius*) and Norway lobster (*Nephrops norvegicus*) (van Gemert and others, 2022; Zimmermann and others, 2021) and integrated models for snapper and grouper stocks (Williams and Shertzer, 2024) and European sea bass (*Dicentrarchus labrax*) (Walker and others, 2020), with some models factoring in environmental variability (Watson and others, 2022b).

Incorporating marine recreational fisheries data into stock assessments helps to refine the determination of the total allowable catch, which guides sustainable harvest strategies (Fowler and others, 2023; Harford and others, 2021) and allocation among sectors (National Academies of Sciences, Engineering and Medicine, 2024). In addition, management strategy evaluation can be used to explore how regulatory changes, such as hook size, minimum length and harvest slot limits, affect recreational harvests, as was done for the red snapper in the Gulf of Mexico (Bohaboy and others, 2022; Garner and others, 2020). In some jurisdictions, fisheries legislation takes into account biological, social and economic factors, prioritizing sustainable yields, equitable catch allocation and socioeconomic benefits (Tidbury and others, 2021), as exemplified by European sea bass management (Cevenini and others, 2023).

In the European Union, the data-collection framework now requires some marine recreational fisheries data, with specific quota allocations (e.g. for bluefin tuna) and bag limits (e.g. for dolphinfish). However, the Common Fisheries Policy's focus on commercial objectives, such as maximum sustainable yield, does not align well with recreational fisheries (Grati and others, 2024), the aim of which is often to maximize fisher satisfaction, which may require maintaining biomass levels above those typically associated with maximum sustainable yield (Birdsong and others, 2021; Johnston and others, 2010). Harmonized objectives that recognize the social and experiential goals of recreational fisheries are therefore essential for effective management (Grati and others, 2024).

Tensions are common in fisheries that are targeted by both the recreational and commercial sectors, especially

in cases where stocks are declining. In some countries (e.g. Australia, New Zealand and the United States), "explicit allocation" of catch shares — assigning fixed portions of total allowable catch based on historical data — can mitigate conflicts, but the use of historical data may also create conflict if either sector is in a growth phase or the historical representation of recreational catch share is inaccurate (Bess and Rallapudi, 2007; McShane and others, 2021). Elsewhere, allocation is implicit, with management measures indirectly influencing catch distribution. This lack of transparency can hinder balanced societal benefits, as seen with European species such as sea bass and western Baltic cod (Hyder and others, 2020). A transparent and consistent approach to explicitly allocating catch shares to recreational and commercial fisheries, taking into account both social and economic objectives and benefits, is necessary (Hyder and others, 2020), but currently not in place in most countries. Socioecological systems perspectives and economic valuation can be used to implement such an approach and have been applied to some recreational fisheries (Arlinghaus and others, 2017). Adaptive approaches are flexible and involve stakeholders rather than being top-down, but there are challenges in representing socioecological feedback processes and external drivers of changes that are beyond the control of fisheries managers. Other constraints to implementing an adaptive governance framework involve defining and representing multiple objectives that account for social, ecological and economic factors and that go beyond traditional objectives, such as maximum sustainable yield or fisheries reference points – for example, if objectives were to focus on maximizing the economic value of all sectors of fisheries instead of just maximum sustainable yield, and related fisheries reference points (Arlinghaus and others, 2019). However, establishing such systems would place even greater demands on data. It would also involve difficult negotiations about objectives and performance criteria, which are well beyond the current capabilities of most fisheries governance systems.

Only about one third of national fisheries policies support co-management in recreational fisheries, which is essential for stakeholder collaboration, sustainable resource use, compliance and local knowledge integration (Ehrlich and others, 2023; Potts and others, 2020). Co-management is challenging in recreational fisheries due to the diversity and fragmented organization of recreational fishers. Angler management organizations can facilitate stakeholder integration in management processes by sharing management responsibilities and fostering outreach (Arlinghaus and others, 2019), especially if they are broadly representative and independently funded.

Whatever mechanism is applied to manage recreational fisheries, success depends on minimizing non-compliance (Battista and others, 2018). Non-compliance may be unintentional or intentional. Marine recreational fisheries regulations vary widely, from permit systems to spatial and temporal closures. Compliance is a critical determinant of regulatory success, though only 11% of surveyed countries reported effective compliance (Potts and others, 2020). Non-compliance is challenging to estimate as it requires data from within regulatory frameworks, often collected through covert operations (Ban and others, 2022; Bova and others, 2024). Many jurisdictions have implemented enforcement programmes and legal frameworks with punitive measures to address non-compliance (Moutopoulos and others, 2020). Since these approaches have not been universally effective (Bova and others, 2024), there is growing recognition that normative approaches may be more suitable and cost-effective for regulating deliberate non-compliance and improved education for addressing unintentional non-compliance (Arlinghaus and others, 2010, 2012; Bova and others, 2017; Mackay and others, 2018).

Normative approaches may prove to be more effective and cost-efficient to regulate all non-compliance when compared with punitive measures (Bova and others, 2017; Mackay and others, 2018). Many jurisdictions are launching education and awareness campaigns to improve fishers' knowledge and support for fisheries regulations (Lindley and Quinn, 2023), and sector-led stewardship initiatives are also becoming more common. Social norms and networks significantly influence fisher behaviour and can promote accountability and sustainable recreational fishing, whereby fishers accept the need and value of managing their own catch (Arlinghaus and others, 2010, 2012; Cooke and others, 2019). Social dynamics, especially within organized clubs, on social media and through ambassadors, drive adherence to sustainable practices. Recalibration of social norms through word of mouth and social media networks can be highly effective (Allison and others, 2023), particularly if those who are sharing the message are highly respected among the target audience. When existing social norms are unsustainable or additional information (i.e. scientific evidence) suggests a need for change, localized interventions that leverage normative

influence have the potential to incentivize behavioural change and seed new norms (Allison and others, 2023; Bova and others, 2017; Danylchuk and others, 2018; Mackay and others, 2018).

Effective examples of educating fishers on best practices to account for post-release mortality include programmes such as Keep Fish Wet (Danylchuk and others, 2018) and Tuna Champions (Tracey and others, 2023), developed collaboratively by scientists, managers and angling leaders. Other efforts have focused on habitat restoration (e.g. OzFish)[2] and broader sector-led contribution to sustainable fisheries (Black, 2023). Once a critical majority has adopted the desired behaviour, social dynamics and pressures (e.g. interpersonal communication, modelling) can trigger widespread shifts, eventually tipping fisheries towards more sustainable outcomes (Tracey and others, 2023).

5. Sustainability pathways

Marine recreational fisheries are intrinsically linked to ecological assets in the marine ecosystem as fish abundance is closely tied to habitats that are affected by aquaculture, commercial fishing, marine parks, port activities, shipping and offshore energy infrastructure (Laubenstein and others, 2023; Turschwell and others, 2022). As interest grows in the blue ocean economy, with both its potential impacts and benefits for recreational fishing (Stephenson and Hobday, 2024), future marine governance will require integrated planning across multiple sectors, agencies and jurisdictions (Kidd and others, 2020; Stephenson and Hobday, 2024; Zaucha and Gee, 2019). In the lead-up to 2030 and beyond, recognizing diverse stakeholder needs, including those of marine recreational fishers, is essential for effective marine spatial planning, particularly in the recreational fishing sector, which offers substantial cultural, social and economic benefits (Hyder and others, 2020) as well as health, well-being and food security advantages (Curran and others, 2023). Integrating recreational fishing into marine spatial planning frameworks would promote social equity and acknowledge its interconnectedness with tourism and conservation (Noble and others, 2019; Voyer and others, 2017). That process starts by acknowledging that marine recreational fishers are important stakeholders with a seat at the table and that their benefits extend well beyond just leisure (Arlinghaus and others, 2019; Grati and others, 2024). Engaging stakeholders through public consultations, advisory committees and workshops ensures that fishers' unique perspectives are considered, which will ultimately lead to effective zoning and other regulations that support responsible practices (Bonsu and others, 2024). This collaborative approach fosters sustainability in marine ecosystems and encourages stewardship among recreational fishers (Ehrlich and others, 2023), and should be a priority for implementation in order to successfully achieve more sustainable oceans by 2050 (Kelly and others, 2022). Implementation will require not only significant change through transformative global governance and political will but also an understanding of the values of recreational fishing beyond economic return (Arlinghaus and others, 2019; Grati and others, 2024).

As marine recreational fisheries typically occur alongside commercial fisheries, there is a critical need for robust data on recreational fisheries to support sustainable practices and sector access (Bess and Rallapudi, 2007; MacKenzie and Cox, 2013b; National Academies of Sciences, Engineering and Medicine, 2021). Unlike for commercial fisheries, mandatory reporting for recreational fishing is rare. Most surveys are voluntary and have a vital role in informing fisheries assessments and management (Fisheries and Oceans Canada (DFO), 2015; Ryan and others, 2016, 2019; Tracey and others, 2022). Survey sampling methods should be probability-based and designed to minimize uncertainty and biases, making the data suitable for broader inferences (Sparrevohn and Storr-Paulsen, 2012; Vølstad and others, 2011). However, survey errors from declining response rates and lower landline usage pose challenges (Bova and others, 2018; Teixeira and others, 2016). Addressing these challenges and increasing the recreational fisher's self-motivation to provide data are critical to maintaining data quality and reliability (Lewin and others, 2023).

Technological innovations are essential for improving data collection and promoting sustainable fishing practices (Cooke and others, 2021; Lennox and others, 2022). Global navigation satellite system-enabled devices and digital platforms, such as mobile apps and social media, allow fishers to record their activities in near real time, providing data on fishing effort, catch, species distribution, environmental conditions and habitat quality

[2] See https://ozfish.org.au.

(Bradley and others, 2019; Venturelli and others, 2017). These tools support data accuracy, reduce biases (Crandall and others, 2018; Johnston and others, 2021) and facilitate the sharing of information on fishing regulations, conservation initiatives and responsible fishing practices. Successfully realizing the potential of technology platforms to accurately and precisely record and collate recreational catch and effort data by 2030 will be essential to effective stock assessment and appropriate and recognized resource-sharing, through either direct sector allocations or more dynamic management mechanisms, which may be just over the horizon (Venturelli and others, 2017). By 2050, all sources of mortality will need to be identified, and communities and sectors will need to understand and accept their impacts and the role that they play in maintaining and fostering a vibrant ocean (Bennett and others, 2018; Kelly and others, 2022; Mathevet and others, 2018).

Advanced technologies, such as remote cameras, computer vision and aerial and underwater drones, further enable in-situ monitoring of fishing activities, species populations and habitats. These innovations allow for the assessment of fishing pressure and fish behaviour patterns, which can be integrated into existing monitoring programmes (Flynn and others, 2018; Hartill and others, 2020; Lennox and others, 2022; Signaroli and others, 2024). At the same time, digital reporting methods require survey errors to be evaluated and non-probability sampling biases to be addressed in order to ensure representative and unbiased data collection (Gundelund and others, 2021).

Novel survey designs and statistical approaches, including probability sampling, are being developed to improve data quality and reduce costs (Ferter and others, 2023; Sande and others, 2022). The integration of these technologies into monitoring programmes is supported by appropriate governance frameworks for data collection, storage and dissemination, fostering responsible fishing and data-driven conservation efforts (Andrachuk and others, 2019; Johnson and others, 2021).

As the recreational fishing community is large, harnessing the power of people through a scientific-community-accepted, output-focused "citizen science" programme should be a priority in the lead-up to 2030 (Gundelund and others, 2020; Kelly and others, 2022; Whyte and others, 2024). Focus should be placed on how to collect data that are of use and relevance to the successful management of marine resources (Arlinghaus and others, 2019; MacKenzie and Cox, 2013a). The active involvement of fishers is essential for collecting data on and monitoring marine recreational fisheries. Effective data collection requires frameworks that support fisher engagement, encouraging individuals to share fishing activity data with researchers, who then provide aggregated insights back to the community (Ison and others, 2024). Data collected can be informative and can be used as the basis for, or as a supplement to, a range of scientific studies (Graba-Landry and others, 2023; Stuart-Smith and others, 2018). Increased engagement between researchers and fishers — "inform", "consult", "involve", "collaborate" and "empower" — enhances fisheries management by fostering a cooperative approach between management and research agencies and fishing communities (Johnston and others, 2024; Mason and others, 2017). This involvement improves stewardship, promotes responsible fishing practices and supports conservation efforts (Pita and others, 2020; Shephard and others, 2023). Integrating local knowledge with scientific methods offers a more holistic approach to fisheries management, enabling adaptive frameworks that respond effectively to fish population changes and marine spatial planning needs (Chollett and others, 2022).

Transdisciplinary governance, whereby fishers, scientists and policymakers co-develop solutions, has facilitated practical approaches to fisheries management (Said and others, 2018). Such collaboration also builds community resilience, supporting sustainable fisheries and healthy ecosystems. Recognizing the impact of habitat degradation on fisheries productivity, communities worldwide have initiated habitat restoration projects, including seagrass (Adams and others, 2024; Orth and others, 2020) and oyster reefs (Crawford and others, 2020; Gillies and others, 2020). These efforts align with the United Nations Decade on Ecosystem Restoration (2021–2030), under which the restoration of coastal and ocean habitats that are vital for fisheries and tourism sectors is prioritized (Waltham and others, 2020; Young and Schwartz, 2019).

6. Conclusions

Marine recreational fishing is a popular activity performed within a large fraction of the world's EEZs, with significant economic and ecological implications, particularly for coastal ecosystems. Marine recreational fisheries generate billions annually, especially in developed countries, supporting local communities through job creation and encouraging marine stewardship. Despite these benefits, marine recreational fishers are not considered key stakeholders everywhere and the activity itself raises sustainability concerns in connection with overfishing, catch-and-release mortality, habitat disturbance, pollution and invasive species introduction, as well as conflicts with other fisheries sectors and conservation groups. The rising fishing pressure, fuelled by technological advancements and urbanization, often lacks effective regulation, recreational fishing might pressure stocks already declining from commercial fishing and there is a lack of comprehensive data reporting and regulation, especially in remote areas.

Ecosystem-based fisheries management and marine spatial planning are aimed at balancing the needs of recreational and commercial fishing sectors and other interests (e.g. conservation) while promoting sustainable practices. These frameworks emphasize data reliability, transparent catch allocation and fishing regulations such as spatial closures, but also concerns about equity, access and infrastructure. In many areas, existing management systems have been developed for commercial fisheries, meaning that recreational fisheries can be at best inappropriately regulated and at worst marginalized. There is a need for global governance systems that consider the objectives and benefits of all sectors involved in fishing, including marine recreational fisheries, which are often overlooked or marginalized (Arlinghaus and others, 2019). However, such management is hindered by data-collection gaps, poor capacity, incomplete governance and legislation, inconsistent objectives and regulations, regional differences in culture and governance, and competition over resources between commercial and recreational sectors, as well as access conflicts involving Indigenous communities.

Integrating information on marine recreational fisheries into stock assessments and management strategies is essential, yet operational objectives, data quality and performance metrics that go beyond simple management of yield and instead consider full recreational fisheries benefits are lacking. Co-management and adaptive approaches encourage collaboration among stakeholders, fostering conservation and sustainable resource use. Advanced digital tools and community science initiatives can enhance data collection and promote sustainable fishing practices. In addition, social equity issues, including gender and racial participation barriers, and environmental concerns such as lost gear, present challenges to the social licence of marine recreational fisheries.

To support sustainable marine recreational fisheries, new frameworks must address ecological, economic and social aspects, including improved regulatory compliance, cost recovery models, data integration and mechanisms to promote social development. Effective marine spatial planning, combined with fisher engagement in monitoring, can ensure the long-term viability of marine recreational fisheries and ecosystem sustainability by aligning management with biological, social and economic goals, so that marine recreational fisheries can be a flourishing component of sustainable ocean use into the future.

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