

Globalizing recreational fisheries should not globalize non-native species

Jingrui Sun^{1,2,3*}, Phillip J. Haubrock^{4,5,6}, Ronaldo Sousa⁷, Teun Everts^{8,9}, Huiying Yang¹, Hugh J. MacIsaac^{10,11}, Neil Angelo Abreo^{4,12}, Shams M. Galib¹³, Ali Serhan Tarkan^{6,14,15}, J. Robert Britton⁵, Julian D. Olden¹⁶

¹ Yunnan Key Laboratory of International Rivers and Transboundary Eco-Security, Institute of International Rivers and Eco-Security, Yunnan University, Kunming 650091, China

² State Key Laboratory for Vegetation Structure, Function and Construction (VegLab), Kunming, China

³ Ministry of Education Key Laboratory for Transboundary Eco-Security of Southwest China, Yunnan University, Kunming, 650091, China

⁴ University of South Bohemia in České Budějovice, Faculty of Fisheries and Protection of Waters, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Zátíší 728/II, 389 01 Vodňany, Czech Republic

⁵ School of Life and Environmental Sciences, Faculty of Health, Environmental and Medical Sciences, Bournemouth University, Poole, Dorset, The United Kingdom

⁶ Gulf University for Science and Technology, Department of Mathematics and Natural Sciences, Kuwait

⁷ CBMA – Centre for Molecular and Environmental Biology/ARNET-Aquatic Research Network/ IB-S, Institute of Science and Innovation for Bio-Sustainability, Department of Biology, University of Minho, Campus Gualtar, 4710-057 Braga, Portugal.

⁸ Research Institute for Nature and Forest (INBO), Genetic Diversity, Geraardsbergen, Belgium

⁹ KU Leuven, Department of Biology, Heverlee, Belgium

¹⁰ Great Lakes Institute for Environmental Research, University of Windsor, Windsor, Canada

¹¹ Yunnan Key Laboratory of Ecological Protection and Resource Utilization of River-lake Networks, School of Ecology and Environmental Science, Yunnan University, Kunming, China

¹² Mapua Malayan Colleges Mindanao, College of Health Sciences, Davao City, Philippines

¹³ Department of Fisheries, University of Rajshahi, Rajshahi 6205, Bangladesh

¹⁴ University of Lodz, Faculty of Biology and Environmental Protection, Department of Ecology and Vertebrate Zoology, Lodz, Poland

¹⁵ Department of Basic Sciences, Faculty of Fisheries, Muğla Sıtkı Koçman University, Muğla, Türkiye

¹⁶ School of Aquatic and Fishery Sciences, University of Washington, Seattle, Washington, United States

*Correspondence Jingrui Sun; Email: jingrui.sun@ynu.edu.cn

Abstract

Recreational fishing continues to expand globally, generating substantial economic, cultural, and social benefits. Yet with this globalization in fishing opportunities comes more diverse pathways for biological invasions. Major concerns are surfacing that the intentional stocking of non-native fishes to initiate or enhance recreational fisheries may facilitate the unsanctioned spread of the target species, as well as the introduction of a host of other species through unintentional pathways. These invasion risks become especially difficult to manage once non-native sport fishes are well established and embedded in local economies, tournament cultures, and angling identities, reinforcing ecological and socioeconomic feedbacks that drive socio-ecological lock-in. Using widely introduced sport fishes as examples, we highlight governance gaps between recreational-fishery development and biosecurity measures associated with invasive species. We propose basin-native target species, context-specific tournament rules, strict containment of non-native fishes in closed waters, and stronger angler biosecurity to reconcile recreational fisheries with biodiversity conservation.

Keywords

Angling; Biological invasions; Biosecurity; Socio-ecological lock-in; Intentional stocking; Environmental governance

Main

Recreational fishing is a global form of nature-based recreation (Arlinghaus et al., 2019; Cooke & Cowx, 2004), with an estimated 12% of the world population participating in 2000 (Cooke & Cowx, 2004). Across industrialised countries, participation is similarly substantial, averaging close to 11% of the population across 27 countries in North America, Europe and Oceania (Arlinghaus et al., 2015). Global recreational fisheries have developed around a diversity of target freshwater fishes, including large-bodied species of the Salmonidae (salmon and trout) and Cyprinidae (carp) families, as well as species of tilapia, perch, pike, catfish, and black bass (Crawford & Muir, 2008; Long & Seguy, 2024; Rapp et al., 2008). These fisheries generate economic and cultural benefits by supporting tourism, local livelihoods, angling identities, and recreational communities (Seguy & Long, 2021). However, recreational fisheries have also contributed to the accidental and deliberate movement of fishes beyond their native ranges (Cucherousset et al., 2021; Rahel, 2004; Tarkan, Mol, et al., 2023), as commercial operators, fishery managers, and even anglers seek to create or enhance target fisheries (Cambray, 2003; Carpio et al., 2019; Donald, 1987; Eby et al., 2006; Pister, 2001). As such, these activities increase the risk of non-native species transport, establishment, and subsequent ecological and socio-economic impacts (Cambray, 2003; Carpio et al., 2019; Cucherousset & Olden, 2011). Recreational fisheries, much like other introduction pathways that include aquaculture (Gozlan, Britton, et al., 2010), ornamental trade (Chan et al., 2019), commercial and inland shipping (Bailey, 2015), live food fish trade, and religious releases can thus unintentionally pose a severe risk for freshwater ecosystem health (Keller & Lodge, 2007).

Recreational fishing can create high-risk invasion pathways and cause ecological impacts

Recreational fishing tournaments succeed because they create demand for reliable target fish populations that support structured sporting systems and fuel enthusiasm, investment, and identity (Yoder, 1997). Venues that produce larger or more numerous fish become more popular, and anglers and organizers benefit when fish are abundant and catchable across multiple events (Box 1). When tournament circuits expand beyond the native range of their target species, they can interact with broader recreational-fishing demand to encourage ecologically risky practices including stocking fish into open or semi-open waters, moving fish between sites and river basins, maintaining non-native predators as recreational assets, or releasing captured fish after weigh-in to preserve future catches (Britton & Orsi, 2012; Carpio et al., 2019; Hickley & Chare, 2004; Rahel, 2004; Tarkan, Haubrock, et al., 2023).

Promoting a recreational fishing industry in one region can become risky if it creates incentives to stock, move, retain, or release non-native target species elsewhere (Fernández-Delgado & Herrera, 2026). Recreational fishing opportunities involving non-native species are driven by the novelty and

desirability to catch new and exciting fish species (Hargrove et al., 2015), but it raises a broader sustainability question: how can countries expand recreational fisheries without creating new high-risk pathways for biological invasions? The benefits of globalizing angling opportunities in support of economies, outdoor culture, and environmental stewardship should not outweigh potential costs associated with the spread of non-native sport fish (Shephard et al., 2023).

BOX 1 | Black bass fishing as an illustrative example

Black bass (*Micropterus* spp.) fishing is among the most commercially successful and internationally recognizable recreational fishing cultures (Cooke, 2026). Originating in North America, this sport-fishing model is built around specialized equipment, organized tournament circuits, commercial sponsorship, media exposure, and ranking-based qualification systems. In the USA, black bass fishing attracts a total of 9.6 million anglers (approximately 32% of all anglers) and generates a combined fishing effort of up to 117 million days (U.S. Department of the Interior et al., 2016). Clearly, black bass fishing is a sport, supporting a business worth US \$10 billion (direct expenditure) in the 2015/2016 fishing season alone (U.S. Department of the Interior et al., 2016), and, in many regions, a source of public support for fisheries management.

Globally, black bass species have been introduced to at least 72 countries for multiple reasons, including aquaculture and recreational fishing (Costantini et al., 2023; Long & Seguy, 2024; South et al., 2022) and groups from 28 countries participate in high-profile black bass tournament systems, such as the Black Bass World Championship, B.A.S.S. Nation, or Major League Fishing (Long & Seguy, 2024). Black bass are native and culturally embedded sport fishes in North America, but even here, in their native ranges, black bass fisheries are not ecologically neutral, with the moving of these piscivorous fishes among lakes or basins affecting local genetic integrity and creating conservation trade-offs (Thompson et al., 2016). Outside their native range, they can become invasive predators and negatively affect native species (Abreo et al., 2026). Indeed, in their introduced range, the environmental risk posed by bass is high (Cambray, 2003), especially given their broad environmental tolerances (Abreo et al., 2026), and has resulted in species like Largemouth bass (*Micropterus nigricans*) being considered among the 100 of the world's worst invasive species (Cambray, 2003; Luque et al., 2014). Black bass are only one example of this broader pattern, and similar ecological and governance tensions occur with introduced salmonids and other globally valued sport fishes (Sharpe et al., 2017). Introduction of species lacking co-evolutionary histories with species in recipient communities tend to produce large ecological impacts (Ricciardi & Atkinson, 2004) .

Just how big is this risk? A European review found that almost a quarter of freshwater fish introduced into Europe during the previous century were released primarily for angling purposes (Carpio et al., 2019). Work on Iberian anglers showed that even when risky behaviours (e.g. bait release, intentional introductions) are performed by only a few anglers, they can nevertheless

support large propagule pressure (i.e. the number, frequency, and quality of individuals introduced into a recipient location; Simberloff, 2009), positively influencing establishment potential. Specifically, researchers estimated 273,600 bait-discharge events and 140,000 intentional introduction events occur each year in the Iberian Peninsula alone (Banha et al., 2024). Similarly, Belgian anglers unintentionally transfer organisms during a single outing (25% of anglers) or by transporting them from abroad (45% of anglers), while only a small minority of anglers (8%) adhere to the full check-clean-dry routine after each trip (Reniers et al., 2025). In Canada, Adeli et al. (2026) reported that 19% of live bait users released live bait, and McEachran et al. (2023) found that 20% of anglers released baitfish in Minnesota (USA) waters even though the practice is illegal.

Once non-native sport fishes establish self-sustaining populations and spread, they can generate ecological impacts in recipient ecosystems (Box 1; Haubrock, Tarkan, et al., 2026). This creates a “beloved sport fish versus feared invader” problem because the very attributes that make angling species attractive to anglers, such as large size, aggressive strikes, piscivory, adaptability, and strong cultural branding, can also make them highly problematic (Abreo et al., 2026; South et al., 2022). For instance, fish introduced for the creation of sport fisheries also tend to feed at higher trophic levels through piscivory, increasing their ecological risk for native fish diversity and cascading effects to lower trophic levels (Bradley et al., 2019; Britton & Orsi, 2012; Crawford & Muir, 2008; Cucherousset & Olden, 2011; Rapp et al., 2008). Some of these species can even link different ecosystems through changes in resource subsidy dynamics (Alves et al., 2026). For example, invasive salmonids reduce the abundance of emergent aquatic insects via direct predation, weakening the flux of aquatic prey to riparian consumers such as spiders, birds and bats (Nakano & Murakami, 2001). Simultaneously, invasive salmonids shift terrestrial invertebrate inputs to native fish by direct consumption or changing native fish behaviour and habitat use (Baxter et al., 2004). In addition, these species provide sea-derived nutrients to stream and forest food webs when they spawn and die. These nutrient pulses benefit a wide range of organisms, including invertebrates, birds, and mammals (Dunlop et al., 2021; Muñoz et al., 2021, 2022). Overall, salmonid invasions disrupt cross-ecosystem energy flows with effects on land, water and sea, with cascading consequences for the entire food-webs that remain poorly quantified (Alves et al., 2026). Their history shows that the globalization of sport-fishing cultures can leave lasting ecological legacies when recreational demand is not aligned with biogeography and biosecurity considerations (Cambray, 2003).

Recreational-fishery introductions may also generate secondary invasion risks when associated organisms are moved together with, or in support of, target sport fishes (Table 1). Non-native prey or forage species may be introduced to sustain recreational predators. In European mountain lakes and streams, for example, minnows (*Phoxinus* spp.) have been introduced by anglers as live bait for

salmonids, and sometimes under the belief that they would provide forage for game fishes (Davies et al., 2013; Garcia-Raventós et al., 2020; Miró & Ventura, 2015; Tiberti et al., 2022). Recreational fisheries can then co-introduce parasites and pathogens carried by stocked fish, live bait, or bait water (Brynildsrud et al., 2014; Davies et al., 2013; McEachran et al., 2023). For example, stocked salmonids may transport *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (Brynildsrud et al., 2014). In the UK, introduced Wels catfish (*Silurus glanis*) carried non-native parasites, including *Thaparocleidus vistulensis* and *Ergasilus sieboldi* (Reading et al., 2012). Largemouth bass (*Micropterus nigricans*), specifically, may have co-introduced at least seven parasitic organisms across its non-native ranges (Abreo et al., 2026). Recreational fisheries thus are major introduction pathways for many non-native species globally (Table 1).

Table 1. Recreational fishery-related introduction pathways and representative non-native taxa. Role indicates whether the taxon is the primary organism intentionally introduced to support recreational fisheries, or a secondary organism co-introduced through the same pathway.

Pathways	Role	Taxonomic group	Representative species	References
Intentional stocking	Primary	Fish	<i>Oncorhynchus mykiss</i> ; <i>Salmo trutta</i> ; <i>Micropterus nigricans</i> ; <i>Cyprinus carpio</i>	Britton et al., 2010; Burnett et al., 2023; Schindler et al., 2001
		Invertebrate	<i>Faxonius rusticus</i>	Hamr, 2024
	Secondary	Fish	<i>Pseudorasbora parva</i>	Gozlan, Andreou, et al., 2010
		Invertebrate	<i>Thaparocleidus vistulensis</i> ; <i>Ergasilus sieboldi</i>	Reading et al., 2012
		Bacteria	<i>Renibacterium salmoninarum</i>	Brynildsrud et al., 2014
Live Bait	Primary	Fish	<i>Phoxinus sp.</i> <i>Richardsonius balteatus</i> <i>Pimephales promelas</i>	Kilian et al., 2012; Miró & Ventura, 2015; T. W. Smith et al., 2021; Tiberti et al., 2022
		Invertebrate	<i>Cherax quadricarinatus</i> ; <i>Perinereis linea</i> ; <i>Glycera dibranchiata</i>	Akmal et al., 2024; Cameron et al., 2007; Font et al., 2018
	Secondary	Plant	<i>Ascophyllum nodosum</i> ; <i>Cladophora ruchingeri</i> ; <i>Alexandrium fundyense</i>	Haska et al., 2012
Fishing gear and equipment	Secondary	Invertebrate	<i>Dreissena polymorpha</i> ; <i>Bythotrephes sp.</i> ; <i>Dikerogammarus villosus</i>	Branstrator et al., 2021; Frischer et al., 2005; E. R. C. Smith et al., 2020

		Plant	<i>Myriophyllum spicatum</i> ; <i>Myriophyllum aquaticum</i>	Weir et al., 2022
Release by angler	Primary	Fish	<i>Perca fluviatilis</i> <i>Micropterus nigricans</i> ; <i>Abramis brama</i>	Banha et al., 2024; Esposito et al., 2024; Yürekli et al., 2024

When recreational benefits make non-native fish more challenging to manage

In many regions, non-native sport fishes support significant economic, cultural, and social benefits (Hickley et al., 2015; Hickley & Chare, 2004; Sax et al., 2022). These benefits explain why such fisheries are promoted by local governments, commercial operators, and anglers (Seguy & Long, 2021), especially where recreational fisheries are viewed as tools for rural development or post-capture-fishery economic transition. A key sustainability problem is that these benefits often appear earlier and are more visible than ecological costs, which are often not considered prior to the introduction. A newly created sport fishery can quickly attract visitors, investment, media attention, and local support. The Ebro River basin in Spain provides a prominent example of recreational fisheries associated with introduced European catfish (*Silurus glanis*). The species was deliberately introduced for recreational fishing in 1974, and catfish-oriented fishing tourism began to develop in the late 1980s and early 1990s, subsequently evolving into an internationally recognized trophy-fishing industry supported by professional guides and tourism businesses (Cucherousset et al., 2018; Rodríguez-Labajos, 2015). In 2024, approximately 25,500 anglers from around the world visited the Mequinenza fishing areas, generating nearly 69,000 daily fishing permits (Ayuntamiento de Mequinenza, 2025). Although these figures include anglers targeting other species, such as common carp (also non-native species), *S. glanis* is a major attraction underpinning the region's international recreational fishing tourism. Ecological impacts, by contrast, may take longer to emerge, may occur downstream or outside the managed area, and may be harder to attribute to a specific introduction owing to multiple operating stressors (Haubrock, Everts, et al., 2026). Moreover, stakeholders are subject to different suites of benefits and costs, which manifest over different time scales, and are viewed from different socioecological perspectives, complicating cost-benefit analyses and sustainable management (Carneiro et al., 2024; Sangma et al., 2025).

Once a non-native target fish becomes embedded in local economies and angling identities, management becomes politically and socially difficult, even when ecological risks are recognized (Pascual et al., 2009; Woodford et al., 2016). We describe this process as 'socio-ecological lock-in', whereby the establishment and spread of a non-native sport fish become increasingly coupled with economic benefits, tournament cultures, commercial interests, and angler identities when increasingly embraced by human society (Figure 1; Box 2). At this stage, suppression or eradication may be opposed because it is both technically challenging, and the species has become part of a

recreational economy and cultural landscape (Jarić et al., 2025). For example, in the Pacific Northwest United States, non-native smallmouth bass (*Micropterus dolomieu*) support a substantial recreational fishery while also posing risks to ESA-listed Pacific salmon. In 2006, black bass fisheries in Idaho, Oregon and Washington involved approximately 199,000 anglers, 2.2 million fishing days and an estimated economic value of over US\$65 million (Carey et al., 2011). This economic and recreational importance helps explain why changing slot or size limits on captures or mandatory retention (kill) control measures are socially difficult, especially because many bass anglers practice catch-and-release and oppose destroying individuals (Nishizawa et al., 2006).

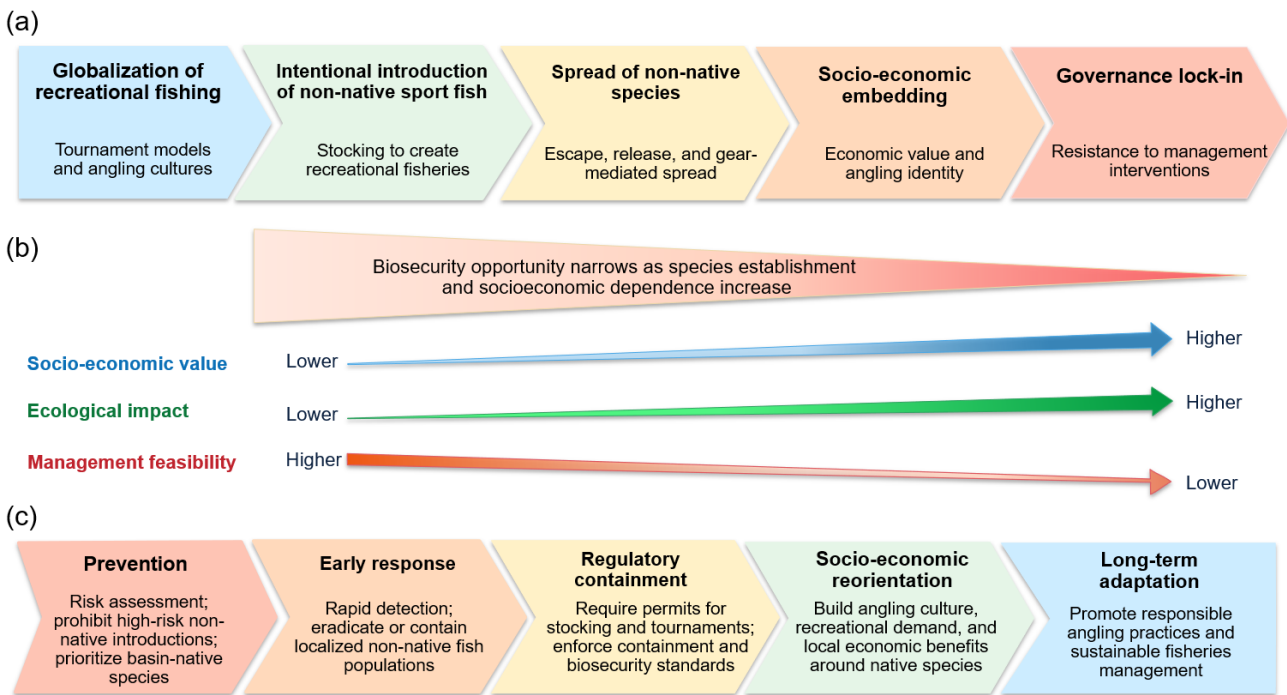


Figure 1. Socio-ecological lock-in of non-native recreational fisheries. (a) Conceptual progression from the globalization of recreational fishing to intentional introduction of non-native sport fish, subsequent spread of non-native species, socio-economic embedding, and eventual governance lock-in. (b) Along this progression, socio-economic value and ecological impacts are expected to increase, whereas management feasibility declines due to increasing propagule pressure, spread, and socio-cultural oppression. The opportunity for effective management therefore narrows as non-native species establish viable populations and spread, and recreational fisheries become increasingly embedded in local economies, tournament systems, and angling cultures. (c) Stage-specific management interventions, progressing from prevention and early response to containment, socio-economic reorientation, and long-term adaptation. These measures emphasize preventing high-risk introductions, controlling further spread, redirecting recreational and economic benefits towards basin-native species, reducing ecological impacts, and promoting responsible angling practices and sustainable fisheries management rather than the further introduction of non-native species.

This lock-in effect is central to the governance challenge. Recreational-fishery management should

231 therefore seek to retain the benefits of recreational fisheries while avoiding, to the maximum extent
232 possible, any dependencies on high-risk non-native species (Hickley & Chare, 2004). Biosecurity is
233 most effective before a sport fish becomes economically valuable, culturally normalized, and
234 politically difficult to regulate (Britton et al., 2023; Davies et al., 2013). The optimal scenario is that
235 recreational fisheries are designed around native or low-risk target species from the outset, rather
236 than relying on later control after non-native sport fishes have become established as recreational
237 assets with problematic ecological consequences (Table 2). Invasion science has well-developed
238 risk screening tools and schemes (Copp et al., 2016; Hill et al., 2025) that can be used to identify
239 these low-risk species.

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241 **Box2 | Socio-ecological lock-in across biological invasions**

Socioeconomic dependence on non-native species is not unique to recreational fisheries. In South Africa, commercially valuable invasive acacias and pines have generated conflicts between forestry interests and biodiversity conservation, constraining management options (Kelsch et al., 2020). Cultural attachment to introduced ornamental trees, such as jacarandas, has similarly led to regulatory compromises (Zengeya et al., 2017). In the United States, recreational hunting opportunities and associated economic incentives have been linked to the distribution and expansion of invasive wild pigs (A. L. Smith et al., 2023). These examples illustrate a common challenge: species that provide economic, recreational, or cultural benefits can generate stakeholder resistance to management despite their ecological impacts.

Existing invasion-management frameworks recognize such conflicts and incorporate economic benefits, ecological impacts, and the extent of invasion into management decisions (Sax et al., 2022). Our proposed framework builds on these approaches but focuses specifically on how recreational-fishery development can reinforce biological invasions through intentional stocking, tournament incentives, catch-and-release practices, and angler-mediated dispersal. Unlike many commercially cultivated invasive species, non-native sport fishes may be deliberately maintained in open, connected aquatic systems where their spread becomes increasingly difficult to control. The coupling of these ecological processes with socioeconomic dependence can reinforce socio-ecological lock-in, progressively narrowing management options and highlighting opportunities for early intervention (Ellender et al., 2014).

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247 **Table 2.** Conceptual risk–benefit profiles of some illustrative recreational fishery models. Ecological risk refers
 248 to the likelihood and consequence of transport, establishment, spread of the non-native species, and
 249 ecological impacts of the non-native species, whereas ecological management difficulty refers to the difficulty
 250 of preventing spread, containing populations, or removing socially valued non-native sport fishes.

Recreational fishery model	Socio, economic, and culture values	Ecological risk	Ecological management difficulty
Non-native recreational fishery in fully contained waters	Moderate — commercial value is generated through fishing parks, private ponds, and associated businesses.	Moderate — risk is relatively low only if waters are fully isolated; risk increases if flooding or fish transport creates pathways for escapement.	Moderate — management is feasible if containment, fish-source documentation, inspections, and emergency escape-prevention measures are enforced.
Non-native recreational fishery in open or semi-open waters	High — attractive angling opportunities and local revenue is generated because fish are available in larger and natural water bodies.	High — connected waters increase the probability of establishment, spread of non-native species, and impacts on native species.	High — prevention and control become difficult once fish establish in rivers, lakes, reservoirs, or other flood-connected systems.
Well-established non-native recreational fishery with angler dependence	Very high — the species may become embedded in tourism, tournaments, local economies, angling identities, and public expectations.	High — ecological impacts may be persistent, widespread, and difficult to reverse once self-sustaining populations are established.	Very high — management is constrained by social, political, and economic lock-in; suppression or non-release rules may face resistance from anglers, businesses, or local governments.
Recreational fishery based on basin-native species	High — can support tourism, local livelihoods, angling culture, and community engagement without relying on non-native target species.	Low — invasion risk is low if target species are native to the host basin, although harvest pressure, habitat disturbance, and fish handling still need management.	Low — management can focus on conventional fisheries measures, such as harvest rules, habitat protection, monitoring, and responsible angling practices.

251

252 **Recreational fisheries expose a sustainability governance gap: Insights from China**

253 China provides a timely example of a wider governance challenge facing countries where
 254 recreational fisheries are expanding rapidly (Figure 2). Recreational fisheries are expanding as part
 255 of rural revitalization, tourism development, and fisheries transformation (Ministry of Agriculture of
 256 China, 2012; Yang et al., 2017). Recent statistics show that China's recreational fishery output
 257 value reached CNY¥ 98.9 billion (US\$13.9 billion) in 2024, up 7.1% from the previous year (Ministry
 258 of Agriculture and Rural Affairs of China, 2025). In May 2026, the China B.A.S.S. Nation Open
 259 Series qualifier was held at Baping Wetland International Bass Fishing Park in Guangxi, and
 260 Bassmaster described the event as a milestone for official Bassmaster tournaments entering China
 261 (B.A.S.S., 2026). These developments show how quickly international sport-fishing models can
 262 become linked to domestic recreation and tourism agendas. However, China also has good reasons
 263 to be cautious. The country has invested heavily in freshwater conservation, including major
 264 restrictions on capture fisheries in key river systems and increasing attention to invasive non-native

species. China's Bio-security Law prohibits unauthorized introduction, release, or abandonment of any non-native species (Biosecurity Law of the People's Republic of China, 2020). China has also issued management measures for invasive non-native species that emphasize prevention, source control, integrated management, interdepartmental coordination, and public participation (Ministry of Agriculture and Rural Affairs of the People's Republic of China et al., 2022).



Figure 2. Representative recreational fish species illustrating the links between fishing demand, species introductions and ecological risk. The upper panels show three species introduced in China for recreational fishing: (a) largemouth bass (*Micropterus nigricans*), (b) rainbow trout (*Oncorhynchus mykiss*) and (c) tilapia (*Oreochromis niloticus*). All three are also widely recognized as invasive fishes in many regions outside their native ranges. The lower panels show (d) mirror/common carp (*Cyprinus carpio*) caught in England, illustrating how a species native to China and other parts of Eurasia has also become an established recreational fish outside its native range, and (e) Chinese largemouth catfish (*Silurus meridionalis*), a species native to southern China but translocated to other parts of China for recreational fishing, highlighting the importance of basin-native fisheries that use species native to the recipient basin rather than merely native at the national scale.. Photos (a), (b), (d), and (e) are copyrighted by Jingrui Sun; photograph (c) is copyrighted by Junhao Yu.

The policy gap is that organized angling and sport-fish markets can fall between existing regulatory

categories (Hickley & Chare, 2004). Recreational angling venues can be treated mainly as tourism, sport, or business activities rather than as potential biological introduction pathways. Yet, these actions can normalize the idea that non-native sport fishes are recreational assets that should be maintained, moved, and protected (B. M. Johnson et al., 2009). The problem becomes even more pronounced when the boundary between closed and open waters is unclear. Chinese landscapes contain reservoirs, wetlands, lakes, and natural waterways connected seasonally by floods, drainage, or human water management. Even if a competition were held in an 'isolated reservoir', risks remain if the venue is connected to natural waters, if fish escape during floods (Davies & Britton, 2016), or if anglers later release target fish into nearby rivers and reservoirs to create informal fishing spots (B. M. Johnson et al., 2009; P. T. Johnson et al., 2008).

Public messaging is another important gap. Invasion policy characteristically tells the public not to release non-native species. Recreational fishing marketing may, at the same time, celebrate non-native sport fish as exciting, valuable, and worthy of release. If a non-native predator is framed mainly as a premium sport fish, public support for containment, non-release, or removal may weaken, further reinforcing the socio-ecological lock-in (Figure 1). The socio-ecological disjuncture is not unique to China; many countries manage invasive species in conservation policy while tolerating or even supporting non-native sport fisheries because they provide economic benefits (Ellender et al., 2014; Jackson et al., 2004; Ota et al., 2019; Pascual et al., 2009; Weyl et al., 2015). In Chilean and Argentine Patagonia, non-native salmonids have supported economically valuable recreational fisheries despite their substantial ecological effects (Pascual et al., 2009). In Brazil, legislation at municipal and state levels has sought to protect introduced peacock bass (*Cichla* spp.), reflecting their perceived value for sport fishing, tourism, and local economies (Pelicice et al., 2023). Therefore, the challenge is to align recreational fishery development with biosecurity before tournament cultures, supply chains, and angler expectations become entrenched. Fisheries managers, ecologists and policy makers should consider the possible adverse consequences of non-native recreational fish species introductions before fish are stocked, such as through the application of invasion risk assessments (Canavan et al., 2025), as it is entirely possible that management thereafter could develop into a challenging issue (Britton et al., 2023).

Incorporating biosecurity standards for recreational fisheries

While recreational fishing clearly belongs in invasion-policy discussions alongside aquaculture, aquarium releases, live-food trade, and shipping (Gozlan, Britton, et al., 2010), it is often underacknowledged relative to these better-known high-risk invasion pathways. Global recreational fishing should export sporting skill, environmental responsibility, and angler stewardship (Arlinghaus et al., 2012; Cooke et al., 2019; Shephard et al., 2023), not the assumption that globally recognized sport fish are suitable everywhere. Without explicit biosecurity rules, the economic logic of sport

fishing can conflict with biodiversity conservation (Britton & Orsi, 2012; Hickley & Chare, 2004).

The evidence synthesized above highlights four interconnected biosecurity challenges: the introduction of non-native target fishes, the potential for tournament practices to facilitate their persistence and spread, escape risks from recreational fishing facilities, and the unintentional transfer of organisms by anglers. Accordingly, we propose four complementary management principles that directly address these risks. First, as balancing the relationship between economic value and ecological risk seems challenging (Britton & Orsi, 2012), natural-water tournaments should be based on native species, not just at the national scale but species originating from the same basin (Sun, Haubrock, Tarkan, et al., 2026a, 2026b). Basin-level nativity matters: a species native to one river basin may be non-native in another. Tournament rules should therefore be localized rather than applied wholesale, with target species selected from basin-native fishes and cross-basin stocking or translocation strictly prohibited (Liu et al., 2026). This is especially important for isolated river basins, as they tend to support high proportions of endemic fishes. Second, tournament rules should be species- and context-specific. Catch-and-release can reduce harm for native target fishes, but automatic release is inappropriate for high-risk non-native species in open waters given risks of uncontrolled spread (Hickley & Chare, 2004). Regulations should specify whether such fishes should be removed, reported, or humanely disposed of under official guidance (Adeli, Neff, et al., 2026). Third, closed commercial waters using non-native sport fish require physical and regulatory containment. Fishing parks that use non-native sport fishes should be separated from natural waters, screened against escapes, inspected after floods, protected from biological vectors able to spread introduced fish, and required to document fish sources. Event permits should distinguish closed artificial ponds from open or semi-open waters. Anglers should become biosecurity partners (Skrzypczak & Karpiński, 2020; E. R. C. Smith et al., 2023) and tournaments should require cleaning, draining, drying, and inspecting boats, trailers, nets, live wells, waders, and other equipment (E. R. C. Smith et al., 2020). Finally, they should also encourage reporting of unusual catches, provide identification guides for non-native species, and collaborate with fisheries agencies and scientists.

Conclusion

Recreational fishing is one of the few biodiversity-related activities that can mobilize large numbers of citizens, businesses, local governments, and rural communities. This widespread enthusiasm makes recreational fishing a valuable component of sustainable tourism and rural development, but it can also be ecologically risky when it involves introducing of non-native species that threaten ecosystem structure and function. Strong social and political support from angling communities, clubs, and associated industries can, however, make the ecological risks of non-native sport fish less visible and management responses more difficult. This is particularly problematic because the

economic and cultural benefits of recreational fisheries are often immediate and visible, whereas ecological costs may emerge gradually and elsewhere. Biosecurity, therefore, needs to precede, rather than follow, the social and political entrenchment of non-native sport fisheries. The globalization of recreational fisheries should focus on exporting skill, stewardship, and excitement—not the ecological burden of invasive sport fish.

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Author contribution statement

JS conceived the study and led the development of the manuscript. JS led the writing of the original draft. PJH, RS, TE, HY, HJM, NAA, SMG, AST, JRB, and JDO contributed substantially to the development, drafting, and revision of the manuscript. JS and HY prepared the figures. All authors reviewed and edited the manuscript and approved the final version for submission.

Declaration of interests

The authors declare no competing interests.

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