Chapter 19
Fish Welfare in Recreational Fishing

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Abstract Recreational fishing is a popular activity around the globe, and fish welfare issues related to the activity have received increasing attention in some countries, particularly in central and northern Europe and Australia. This chapter offers an introduction to recreational fishing, reviews literature on fish welfare in relation to recreational fishing and provides an overview of potential biological impacts and ways to reduce such impacts. We first focus on the question on how to reduce impacts on the welfare of the fish during recreational fishing. Second, we describe two case studies highlighting that practical implications of the fish welfare discourse may be disjointed from the scientific information base and be rather about fundamental moral questions about the ethical acceptability of the activity per se. We end by providing an outlook on the future of recreational fishing in the light of the current fish welfare discourse.

Keywords Best practice guidelines · Catch-and-release · Fish welfare · Function-based approach · Recreational fishing · Sublethal impacts

Recreational fishing is a popular activity around the globe (Arlinghaus et al. 2015, 2019). Apart from the recognized biological and socio-economic importance of recreational fishing, fish welfare issues related to the activity have received increasing attention in some countries and in the academic literature (Huntingford et al. 2006; Arlinghaus et al. 2007a, b, 2012b; Cooke and Sneddon 2007; Volpato 2009; Arlinghaus and Schwab 2011). This chapter offers an introduction to recreational

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fishing and reviews literature on fish welfare in relation to recreational fishing. We will focus on the question of how to reduce impacts on the welfare of the fish during recreational fishing and provide an outlook on the future of recreational fishing in the light of the fish welfare discourse. We will not discuss, let alone answer, the question whether recreational fishing in general or angling are ethically acceptable, as this question has no objective solution and strongly depends on personal or cultural values. For example, one can ethically question the practice of catch-and-release as harming fish for no good reason (Volpato 2009), and one can take the stance that it is preferable to kill a recreationally captured fish than to release it (Webster 2005). Alternatively, one can conclude that it may be ethically impermissible to kill fish for human consumption (Bovenkerk and Braithwaite 2016). These extreme examples show how different the moral judgement of the very same practice—to catch and release a fish—can be in recreational fisheries. It is not our role as scientists to say what is right or wrong. Instead, we focus our chapter on the description of how to minimize negative impacts on the welfare of fish. That said, we will also highlight two case studies that show that in the "real world" the fish welfare discourse may be used to fundamentally question the ethical appropriateness of the entire activity. This is done to show that solving biological questions using robust, replicable science in terms of what impacts the well-being of fishes in recreational fishing may be of limited importance in practical fish welfare discourses (Riepe and Arlinghaus 2014).

19.1 A Short Overview of Recreational Fishing

19.1.1 Definitions

Recreational fishing is a diverse activity, and it is therefore challenging to clearly define. Although the separation from commercial fishing seems to be clear-cut as the main motivation for commercial fishing is economic revenue to the individual participant, there are recreational fisheries in which catches can also be sold (e.g. marine recreational fishing in Norway), or where recreational fishing happens in a commercial context (e.g. charter boat fishing). The separation from subsistence fisheries is even more difficult as many recreational fishers have subsistence-like motivations when harvesting fish (Macinko and Schumann 2007; Cooke et al. 2018). Accordingly, definitions of recreational fishing vary (Pawson et al. 2008; FAO 2012; ICES 2013). For example, FAO (2012) defines recreational fishing 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", while ICES (2013) considers recreational fishing as "the capture or attempted capture of living aquatic resources mainly for leisure and/or personal consumption". Pitcher and Hollingworth (2002) acknowledge that recreational fishing is separated from other forms of fishing by being mainly about fun rather than subsistence or economic revenue. However, a necessary component of the "fun" aspect is catching and possibly keeping fish for personal consumption,

which contributes essential nutrients to the recreational harvester (Cooke et al. 2018). Despite being mainly about leisure, recreational fishing is responsible for a large economic activity, but the difference among commercial, subsistence and recreational fishing is that the main actor pursuing the recreational activity (the recreational fisher) is generally not interested in acquiring essential resources for their own survival and thus does not have economic interests himself or herself. Recreational fishing is the prime fishing activity in freshwater of all industrialized nations and grows in importance rapidly with economic development of societies (Arlinghaus et al. 2002; FAO 2012). It is also a common form of fishing in coastal areas, particularly in wealthy countries (Arlinghaus et al. 2019).

Although a range of passive fishing gears is employed by recreational fishers (e.g. gillnets, traps, hook-and-line), the main method used is angling using a rod and a reel (Arlinghaus et al. 2007a). We will therefore mainly focus on angling in this chapter but emphasize that other capture methods common to commercial fisheries (e.g. see Chap. 17) also have fish welfare implications in recreational fisheries. Apart from harvesting their catch, anglers often release a certain proportion of their catch due to regulations or personal motivations. This practice is called catch-and-release (C&R), defined as "the process of capturing fish by using hook and line, mostly assisted by rods and reels, and then releasing live fish back to the waters where they were captured, presumably to survive unharmed" (Arlinghaus et al. 2007a). C&R due to regulations (e.g. minimum landing sizes or bag limits) is referred to as regulatory C&R, while C&R of legally harvestable fish is referred to as voluntary C&R. If all captured fish are released, the term "total C&R" is used. Total C&R is rare in most recreational fisheries except some highly specialized fisheries, while some form of C&R probably occurs in all recreational fisheries worldwide (Arlinghaus et al. 2007a).

19.1.2 Relevance

Recreational fishing is a popular outdoor activity in inland and marine waters around the globe (Arlinghaus et al. 2019). Arlinghaus et al. (2015) estimated that around every tenth member of society engages in recreational fishing; they estimated that there are around 118 million recreational fishers in North America, Europe and Oceania alone. Data on participation rates in other parts of the world are insufficient or lacking entirely, but one can expect that global fishing participation is at least 220 million people (World Bank 2012). A recent study suggests that there might be 220 million anglers in China alone (China Society of Fisheries 2018). Locally high recreational fishing pressures can impact fish stocks (Post et al. 2002; Coleman et al. 2004; Cooke and Cowx 2004; Lewin et al. 2006). Moreover, several studies have shown that marine recreational fishing can account for a significant proportion of the total catch of some species (e.g. Post et al. 2002; Coleman et al. 2004; Strehlow et al. 2012; Herfaut et al. 2013; Brownscombe et al. 2014a; Kleiven et al. 2016; Hyder et al. 2018; Radford et al. 2018). Apart from its biological impacts, recreational

fishing also provides socio-economic benefits, both to the individual fisher (e.g. food, nature experience, education and other personal rewards) and to society (e.g. jobs, social capital, management capital and economic benefits) (Weithman 1999; Arlinghaus and Cooke 2009; Parkkila et al. 2010; Tufts et al. 2015; Lynch et al. 2016; Griffiths et al. 2017), whilst remaining a source of concern for animal liberation and rights advocates (Arlinghaus et al. 2007a, 2012b).

19.1.3 Management Issues in Relation to Fish Welfare

Regulations associated with recreational fishing are highly variable across jurisdictions. In some parts of the world (e.g. most low- and middle-income countries), there is little if any active recreational fisheries management or associated regulatory frameworks (Potts et al. 2020). Some jurisdictions have state/provincial or federal licensing schemes (e.g. all states and provinces in North America and Australia) and science-based regulatory frameworks focused on the largely public waters. In much of Europe, property-right schemes are such that governments typically play small roles in recreational-fisheries management in inland waters but are responsible for marine recreational fisheries. Management of recreational fisheries is diverse; effort, harvest regulations, habitat management and stocking are employed to secure sustainable exploitation (Arlinghaus et al. 2016). As fishing segments can differ substantially in motives and expectations within the same recreational fishery, finding effective tools to manage the fishery as a whole in pursuit of ecological or social goals can be challenging (Radomski et al. 2001; Johnston et al. 2010; Beardmore et al. 2015). Common effort (input) regulations are limiting access through license systems, gear regulations and closed seasons. Output (e.g. harvest) is often regulated through bag limits and minimum-size limits, or other harvest regulations (Lewin et al. 2006). In recent years, total C&R has been used as a management tool to reduce fishing mortality of overexploited fish stocks in selected fisheries while maintaining angling opportunities. However, total C&R as a management tool has led to several fish welfare debates based on moral grounds in selected European countries (Aas et al. 2002; Arlinghaus et al. 2007a). The perspectives range from the capacity of C&R to maintain fish welfare by avoiding excessive mortality (Arlinghaus et al. 2007a, b) to total C&R being fishing for no good (culinary) reason at high welfare costs to the fish (Volpato et al. 2007).

Some non-binding technical guidelines for governance and management of recreational fisheries have been developed (EIFAC 2008; FAO 2012), along with various regional, national and international codes of practice (Arlinghaus et al. 2010), but it is unclear to what extent these have been adopted in the context of welfare (Arlinghaus et al. 2012a). Codes of practice generally promote sustainable recreational and responsible fishing practices that both maintain the population and minimize welfare impacts on angled fish. They can be consulted by individual anglers or used by angling clubs or management agencies to help develop their own outreach materials and internal policies and practices in line with the local and

regional cultural contexts (Arlinghaus et al. 2012a). In general, regulations specific to fish welfare are uncommon across the globe, as it is difficult to regulate very specific angler behaviours (e.g. banning air exposure during C&R). However, in some jurisdictions, such as Germany, there are very specific rules and regulations that constrain practices that are considered unnecessarily harmful to fish welfare. For example, in Germany there are bans on the use of live bait fish, and there is the regulation that one has to kill a harvestable fish immediately after landing by percussive stunning and subsequent debleeding, which kills the fish, to minimize the harm on recreationally caught fish (Arlinghaus et al. 2007a). Moreover, natural resource management agencies have a mandate for education and outreach so there is an opportunity to improve fish welfare independent of any formal regulations (Cooke et al. 2013b).

19.2 Fish Welfare in the Context of Recreational Fishing

Considering fish welfare issues in relation to aquaculture has a long tradition (see Chaps. 1 and 11). During the last decade, increased attention has also been directed towards wild-capture fisheries, and recreational fisheries in particular (e.g. Davie and Kopf 2006; Huntingford et al. 2006; Cooke and Sneddon 2007; Arlinghaus 2008; Metcalfe 2009). In fact, the discussion on welfare of fishes in the context of capture fisheries seems to have been initiated in the context of recreational fisheries, with commercial capture fisheries (Chaps. 17 and 18) following somewhat later and more recently. It is impossible to catch a fish with rod and reel without causing some level of injury (particularly tissue damage from the hook) and physiological disturbance (particularly exercise during the escape response and fight). In addition, the fish are handled, possibly air exposed and either killed or released. In all of this, there is a potential for affecting fish welfare. Apart from the actual capture process (i.e. hooking, fighting and handling), a particular focus has been placed on C&R practices and killing (Davie and Kopf 2006; Huntingford et al. 2006).

There are different approaches to assessing fish welfare (see Chap. 13 for details). Two approaches that are commonly used in the context of recreational fishing are the feelings-based approach and the function-based approach; while the feelings-based approach focuses on the pain and suffering a fish may experience during the capture and release process in angling (Huntingford et al. 2006), the function-based approach focuses on the appropriate functioning of an individual (e.g. physiology, behaviour, health and fitness) (Huntingford et al. 2006; Arlinghaus et al. 2007b). The function-based approach has also been referred to as the pragmatic approach to fish welfare by Arlinghaus et al. (2009b), who suggested its use to objectively measure welfare indicators to assess fish welfare. In fisheries, welfare is about reducing or avoiding negative impacts on the fish. Irrespective of whether the impact is described in terms of feelings or function, most welfare approaches have the same goal, which is to avoid or minimize damage and stress and maintain the well-being of the individual fish as far as possible (Cooke and Sneddon 2007).

Most of the focus on the discussion of fish welfare has been directed towards the negative impacts of recreational fishing. These impacts can be categorized into sublethal and lethal impacts (Arlinghaus et al. 2007a, b). The sublethal impacts can be further portioned into those leading to primary (e.g. hormonal responses), secondary (e.g. mobilization of glucose) and tertiary (e.g. behavioural impairment) stress responses as well as injury and health impacts, with possible consequences for fitness surrogates (e.g. growth) or fitness (e.g. reduction of reproductive output and survival) (reviewed in Arlinghaus et al. 2007a, b; Cooke et al. 2013a). For example, catch-and-release can be a significant stressor and lead to injury (Muoneke and Childress 1994), behavioural changes (Ferter et al. 2015a), impaired feeding performance (Thompson et al. 2018), reduced growth (Klefoth et al. 2011), reduced reproductive output (Richard et al. 2013) and post-release mortality (Hühn and Arlinghaus 2011). However, there are several examples where recreational fishing-related activities have had or have positive impacts on welfare, e.g. by engaging in fisheries management that increases and conserves fish populations or by actions that reduce stressors on individual fishes (e.g. dams) in the wild. For example, anglers have been directly or indirectly involved in the rehabilitation of natural habitats (Granek et al. 2008), which has improved spawning grounds and the general health of the ecosystem (Nilsson et al. 2014). Moreover, the removal of dams enables fish to perform their natural spawning migrations, thereby contributing to improved welfare at the level of individual fishes. In general, the fact that many anglers engage or support fisheries management and improvement of natural habitat (Granek et al. 2008; Cooke et al. 2019) can be considered positive from a fish welfare perspective, despite the concept of fish welfare being an individual concept and not one focused on populations.

19.3 Ways to Promote Welfare

In the following, we will highlight the various areas where recreational fishing induces injury and stress to individual fish, thereby negatively affecting fish welfare, and we will also briefly mention ways by which such impacts could be minimized or avoided altogether. We will only deal with those issues that have received some level of scientific attention as evidenced by published scientific work. We will present the fish welfare impacts starting from the capture process, followed by the handling, and ultimately release or kill components.

19.3.1 Capture

The capture process has varying impacts on fish welfare depending on the capture method (Davis 2002). To be captured by angling, the fish must be hooked, which is bound to cause physical injury. In general, the fish is attracted by a bait or lure fitted

Fig. 20.1 Deep hooking can have lethal and sublethal impacts on the fish. When deep hooking is a problem, changing to larger artificial lures may reduce hooking in critical locations, as shown in Arlinghaus et al. (2008b) (photographer: Adaptfish IGB)

with a hook, which is ingested (Løkkeborg et al. 2014). Thus, the fish gets hooked in the lips, mouth, gills, esophagus or stomach (Alós et al. 2009; Weltersbach and Strehlow 2013). In some cases, the fish are involuntarily or voluntarily hooked on the outside, which is referred to as foul-hooking or snagging. Depending on the anatomical hooking location, the hook causes varying degrees of injury. When a fish is hooked in the jaws, for example, the injury is less than a fish that is hooked in the gills, the gullet, or other vital tissues (Eckroth et al. 2014; Stålhammar et al. 2014). The anatomical hooking location and the severity of hooking injury depend on several factors including, but not limited to, the hook size and type, lure or bait, fishing method (e.g. passive versus active angling) and size of the fish mouth relative to bait size (e.g. Grixti et al. 2007; Arlinghaus et al. 2008b; Alós et al. 2009). There is a large difference between hook types when it comes to anatomical hooking location. For example, when the hook is swallowed by a fish, traditional J-hooks are more likely to deep-hook a fish compared to circle hooks (Aalbers et al. 2004; Cooke and Suski 2004). The anatomical hooking location also depends on the bait or lure type used and its size (Fig. 20.1). Natural baits (e.g. worms) are more likely to be swallowed than an artificial lure (e.g. metal spoon) (Arlinghaus et al. 2008b), but this is also dependent on the fishing method (Payer et al. 1989; Rapp et al. 2008), and

Fig. 20.2 Once the fish is hooked, it has to be retrieved. Appropriate fishing tackle has to be used to ensure successful retrieval and minimize fighting time (photographer: Keno Ferter)

ultimately the size of the bait in combination with the size of the hooks (Wilde et al. 2003). Passive bait presentation gives the fish time to swallow the hook, while the hook is often set instantly when the bait or lure is actively fished (i.e., retrieved quickly as in fishing with artificial lures) (Schisler and Bergersen 1996; Sullivan et al. 2013). However, the likelihood of foul-hooking a fish might increase when the lure or bait is fished actively, and with particular lure types (e.g. crankbaits with two treble hooks; Arlinghaus et al. 2008b).

Once the fish is hooked, it has to be retrieved (Fig. 20.2). It is important to choose appropriate fishing tackle to ensure successful retrieval and avoid line breakage, which might leave the hook inside the fish (Arlinghaus et al. 2008a; Henry et al. 2009; Pullen et al. 2017). Retrieval or fighting time affects physical exhaustion and depends on factors like rod and line class, fish size and environmental conditions (e.g. water current) (Meka 2004; Meka and McCormick 2005; French et al. 2015). The longer it takes to retrieve a fish, the more exhausted the fish gets, which can have a negative impact on the welfare status (Meka 2004). Fighting time is generally positively correlated with the accumulation of lactate in the blood and muscle, and the plasma concentration of the stress hormone cortisol (Tracey et al. 2016). Higher water temperatures often exacerbate negative impacts on the fish (Gale et al. 2013). The lighter the rod or line class, the longer it will take to retrieve the fish, particularly when the fish is large.

Another factor which has an impact on fish welfare during retrieval is the capture depth. Capture depth does not only affect retrieval time (i.e. the deeper the longer it takes), but can also lead to barotrauma signs in some fish species (Ferter et al. 2015b). Barotrauma is caused when the swim bladder gas expands due to ambient pressure reduction during the forced ascent to the surface, and causes signs like swim

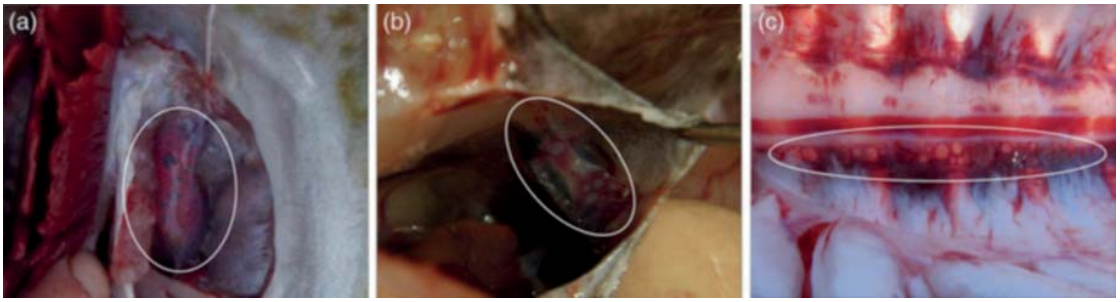

Fig. 20.3 Pictures of gas embolisms in the (**a**) *Vena cardinalis communis*, (**b**) *Vena hepatica* and (**c**) *Vena cardinalis caudalis* of Atlantic cod with barotrauma after rapid decompression. The affected veins are encircled with white rings (taken from Ferter et al. 2015b, licensed by CC BY 4.0)

bladder rupture, gas bubble formation in the blood (Fig. 20.3), exophthalmia and skin bubbles (Hannah et al. 2008; Brown et al. 2012; Ferter et al. 2015b). These signs have species-specific short- to long-lasting impacts on the welfare of the individual fish.

19.3.2 Handling

When the fish is retrieved, it must be landed. There are many different landing techniques that have different welfare implications. Some landing techniques (e.g. the use of a gaff, which consist of a pole with a large hook) are only suitable when the fish is killed immediately after landing. The most common landing techniques are the use of a landing net, hand landing, gaffing or stranding. When the fish is not supposed to be harvested, the best is to de-hook it inside the water to minimize handling and physical contact between the angler and the fish. Landing nets can cause damage to the mucus membrane of the fish, but this damage can be minimized by using knotless, fine-meshed netting (Colotelo and Cooke 2011). Landing the fish by hand can be gentle, but has to be done correctly to avoid injury (Barthel et al. 2003). While handling with towels may lead to mucus injuries during de-hooking, in some fish species, handling with towels has not been found to lead to significant sublethal impacts or death compared to handling with hands only (Schwabe et al. 2014). Nevertheless, the use of towels is more problematic than de-hooking with wet hands underwater. Common hand landing techniques include grabbing the fish in the mouth, under the gill cover or by the tail. When lifting the fish, it is important to support it with both hands to distribute the body weight and avoid damage to the spinal cord (Gould and Grace 2009). Some tools (e.g. lip grips) exist to assist hand landing, but these can cause significant damage on some fish species (Danylchuk et al. 2008). Gaffing the fish can lead to substantial injuries, because the gaff often penetrates vital organs, which is usually lethal. Gaffed fish should thus not be released and immediately killed. However, a fine gaff on a large fish which is pulled through the lips may cause injuries which are not more significant than the hooking injury itself. Stranding the fish (pulling the fish on shore) can lead to significant mucus membrane injury. Moreover, other parts of the

Fig. 20.4 When the fish is supposed to be released again, photographing should be done by lifting the fish shortly out of the water to minimize air exposure. Supporting the fish with both hands is recommended to distribute body weight and avoid damage to the spinal cord (photographer: Will Twardeck)

fish (e.g. the eyes or gills) may be damaged when they come into contact with soil, sand, rocks or vegetation, and thus this method is more damaging than hand landing from a fish welfare perspective.

Once the fish is landed, it is usually de-hooked. If the fish is supposed to be harvested, killing it before de-hooking minimizes impacts on the welfare of the fish (Diggles et al. 2011; FAO 2012) and preserves flesh quality. When the fish is supposed to be released, minimizing or avoiding air exposure is positive for fish welfare as it is generally a stressor for fish and leads to increased physiological disturbance (Arends et al. 1999; Suski et al. 2007; Rapp et al. 2012, 2014), especially when it occurs after exhausted exercise (Ferguson and Tufts 1992). Air exposure may even lead to death in some sensitive species (Arlinghaus and Hallermann 2007). To avoid skin or mucus damage, the captured fish may be placed on a de-hooking mat with a soft rubber surface during de-hooking (Arlinghaus 2007; Stålhammar et al. 2014). De-hooking devices can assist with deep-hooked fish. For some species, it may be beneficial to cut the line of deep-hooked fish close to the mouth instead of trying to de-hook the fish. While some species manage to eject the hook by themselves (Pullen et al. 2019), others can have difficulties (Hall et al. 2009; Weltersbach et al. 2016). Photographing the catch may either be done after the fish has been killed or, when the fish is supposed to be released again, by lifting the fish shortly out of the water to minimize air exposure (Fig. 20.4). Some anglers keep their catch in so-called keep nets or bags prior to killing or release, which may have negative impacts on the fish (Rapp et al. 2012, 2014). Keeping fish in live-wells is also common practice in live-release angling tournaments, and both retaining the fish and the extra handling during weighing can have negative impacts on the fish (Suski et al. 2003b).

19.3.3 Release

If the fish is to be released, doing this as quickly as possible after de-hooking is recommendable to avoid additional handling stress (Fig. 20.5). Only fish without substantial hooking injuries or without other injuries (e.g. due to barotrauma or landing) can be released unharmed, because fish with substantial injuries could suffer from lethal or sublethal short- and long-term impacts. In some regulations, however, the release of some fish species may be mandated independent of the fish condition (i.e. it would be illegal to kill or keep an undersized fish even if mortally wounded). Post-release mortality and sublethal impacts are species-specific and depend on many factors, including, but not limited to, hooking injury, fighting time, capture depth and water temperature (Bartholomew and Bohnsack 2005; Hühn and Arlinghaus 2011). Released fish can show behavioural alterations to varying degrees (Klefoth et al. 2008; Arlinghaus et al. 2009a; Ferter et al. 2015a), which can have implications for welfare. During the breeding season, for example, nesting behaviour could be impaired in some species, which could lead to reproductive failure (Suski et al. 2003a). When predator abundance is high, released fish with abnormal behaviour may be more prone to predation than usual (Brownscombe et al. 2014b). In such situations, it may be beneficial to use recovery bags or boxes in which fish can be held for a certain period of time prior to release (Brownscombe et al. 2013), although some of these may actually produce stress in some fish and lower activity post-release despite physical rehabilitation (Rapp et al. 2012, 2014). Severely exhausted fish may have difficulties recovering and drift downstream when released into strong currents. In these cases, assisted ventilation (i.e. moving the fish back and forth to increase water flow through the gills) is often recommended, but its benefits for the fish are questionable (Robinson et al. 2015). Fish suffering from barotrauma may have difficulties to submerge and are thus easy prey for avian predators. Venting can be used to release excess air from the swim bladder or coelomic cavity, but while this method can have benefits for some species

Fig. 20.5 Releasing the fish carefully shortly after de-hooking reduces sublethal impacts. Atlantic cod without substantial hook injuries or barotrauma return to normal behaviour shortly (<15 h) after the release when handled carefully, as shown in Ferter et al. (2015a) (photographer: Martin Wiech)

(e.g. black sea bass *Centropristis striata*; Collins et al. 1999), it has been shown to have negative or no effects on others (Wilde 2009). Moreover, venting has to be done correctly to avoid injury of vital organs. Another method to assist submergence is the use of release weights. These weights are fastened to the lips of the fish, and lowered to capture depth. Once the fish is recompressed, the weight is released from the fish and retrieved to the surface (Roach et al. 2011).

19.3.4 Killing

Rapidly killing the fish after landing is advisable from a welfare perspective (see Chap. 17 on slaughter). There are different killing methods used by recreational anglers, some of which can have negative implications for welfare (Davie and Kopf 2006). The ideal killing method leads to immediate unconsciousness and fast death. Air asphyxiation by leaving the fish outside the water or putting the fish alive into ice-chilled water is thus not ideal as it can take a long time until the fish dies. More welfare-friendly methods, which are used by recreational anglers and are legally mandated in some countries, are percussive stunning, pithing or ikejime (Davie and Kopf 2006; Diggles 2015) and sometimes shooting the fish (for large species). Guidelines on how to kill fish to promote both welfare and flesh quality have been made available online (e.g. DigsFish Services Pty Ltd 2019). Special tools to kill the fish with a blow to the head, so-called priests, are commercially available and often used to stun the fish prior to bleeding. Cutting the throat without prior stunning can lead to negative welfare as it can take the fish several minutes to die (Jensvoll 2007).

19.3.5 Stocking

An issue related to fish welfare that has as yet not seen a lot of discussion is stocking (Huntingford et al. 2006). While stocking can enhance and preserve fish populations (Lorenzen et al. 2012), the stocked fishes are usually brought into the wild from hatcheries and they are faced not only with the initial rearing phase in artificial environments but also with transport and release stress. As a consequence, stocked fish usually experience greater natural mortality than wild fishes (Lorenzen 2006; Lorenzen et al. 2012), suggesting there may be welfare issues associated with the practice. Throughout the whole process of rearing, fish welfare issues can emerge related to holding and handling-induced stress, which can lead to behavioural impairments and fin damage (Huntingford et al. 2006; Salvanes and Braithwaite 2006). Moreover, transport will affect the welfare of fishes (Barton et al. 1980). After release, when maladapted or when forced in competition with wild fishes, stocked fishes might suffer from large post-release mortality (Hühn et al. 2014), particularly in young fishes (Lorenzen 2005), rendering the stocking of less numerous, but larger,

more robust fishes advisable from a fish welfare perspective. The benefit of stocking for recreational fishing is generally to maintain fish populations and fisheries, and failed stocking events are thus problematic as they are economically wasteful and impact the welfare of those fish that die. The conditions that increase the likelihood of a successful stocking event are equivalent to the conditions that minimize fish welfare impacts: only well-adapted fishes stocked at the right size with as little handling and transport stress as possible will do well after release. Thus, improving stocking for fisheries and for fish welfare goes hand in hand.

19.4 Case Studies on Fish Welfare Debates Related to Recreational Fishing

The following two case studies show how fish welfare has been dealt with in two countries. These case studies show that the ultimate treatment of recreational fishing under a fish welfare perspective often has surprisingly little to do with the purely biological question of how to minimize fish welfare as discussed earlier. The reason is that humans typically judge the moral acceptability of an action in relation to animals based on the motivation of the actor (Olson 2003), and less so by the degree to which a human action affects the welfare of the animal (Riepe and Arlinghaus 2014). Riepe and Arlinghaus (2014) showed that negative evaluations of specific angling practices such as C&R as well as the moral judgement of recreational fishing as a whole were predominantly explained by underlying values and animal rights-related attitudes, and less so or not at all by the degree to which people perceived animals to be able to experience human-like psychological states such as suffering. The following two case studies demonstrate that moral questions directed at the motives of the actor interacting with fishes, rather than scientific questions of how severe the interaction is to the affected fishes, have dictated which practices are considered good from a welfare perspective. This can lead to outcomes that ironically may even harm welfare (Browman et al. 2019).

19.4.1 Animal Welfare Law and Recreational Angling in Germany

Following German animal welfare law, one is only allowed to harm fish, e.g. during recreational fishing, if one has a so-called reasonable, or good-enough, reason. While the specific reasons justifying recreational fishing are not specified in the animal welfare law, a common argument substantiated by a range of court decisions is that a good-enough reason to harm fishes, and thereby affect their welfare negatively, is the actor's motivation to catch fish for dinner (Arlinghaus 2007). In turn, any actions and practices in recreational fishing that are not about getting food for personal

consumption may be considered problematic and have typically been banned or are under normative reprehension by the public and by fellow anglers. Examples are the stocking of legal-sized fish for immediate recapture (because one could directly consume the fish prior to release), voluntary C&R of legally sized fish (which is considered to indicate the lack of a harvest motive and to be mainly about playing with food, Aas et al. 2002) or competitive fishing with associated C&R of the catch. However, if one has a reasonable reason prior to casting the line out into the water, the angler is legally allowed to affect the welfare of fishes negatively, by catching it, by releasing it if undersized or a non-targeted bycatch, and by killing it.

These examples show that judging whether a certain recreational fishing practice is considered permissible or reprehensible from a fish welfare perspective may not be as easily judged from a natural science perspective in terms of what happens to the fish during the process as elaborated in previous sections. For example, the very same practice, e.g. C&R, may be considered legally and morally acceptable if it happens to an undersized fish, say a pike of 49 cm at a minimum-length limit of 50 cm. While the same release event of a pike of 50.5 cm may bring the angler to court if it is done voluntarily in the absence of a general harvest motive. Yet, the fish welfare impacts of the two C&R events to the fish are identical. More importantly, because fishing without a harvest motive is considered unethical in Germany, this essentially means that legally speaking all fish that are caught and legal-sized would have to be taken home for dinner. This in turn means that killing of fish is considered ethically superior to voluntarily releasing part or all catch. However, it is not immediately obvious whether killing or releasing is more problematic from the perspective of the individual focal fish. In fact, one can argue that a fish that is released quickly and in good state may quickly recover from capture- and handling-induced physiological stress, and return into reproductive mode and survive. Likely, from the perspective of the individual fish whose primary interest of life is to stay alive and contribute genes to the next generation (defined as biological fitness), the best situation would be to not be captured at all, followed by catch-and-release without major impacts as the second-best, and being killed as the third-best.

19.4.2 Discussion of Catch-and-Release Practice of Marine Fishes in Norway

Both voluntary and regulatory C&R are common in Norwegian marine recreational fisheries (Ferter et al. 2013, 2015a). Although Norway has implemented a general discard ban, the release of viable fish is allowed according to Norwegian fisheries regulations. This rule applies for both voluntary and regulatory C&R for the most of Norway, but in the Skagerrak voluntary C&R of handheld hook-and-line caught fish has recently been prohibited (Forskrift om utøvelse av fisket i sjøen 2013). Voluntary C&R practice has led to several public debates due to potential welfare issues. Particularly C&R of Atlantic halibut (*Hippoglossus hippoglossus*) has recently

become a hot topic. This species is also one of the most popular voluntary C&R species for marine angling tourists and resident anglers due to its size and powerful endurance during the fight (K. Ferter, personal observation). Thus, this species supports a significant fishing tourism industry in Norway (Borch et al. 2011) and is also important for domestic recreational fishers, particularly in the northern part of Norway. In recent years, voluntary C&R practice for halibut has received substantial media attention and caused several public debates as it is seen as animal abuse for no good reason (e.g. NRK 2016), similar to the case in Germany. The Norwegian Food Safety Authority recently evaluated voluntary C&R of halibut on inquiry of the Ministry of Trade, Industry and Fisheries (Mattilsynet 2015). They concluded that voluntary C&R is problematic from an animal welfare point of view and should be forbidden for all marine species, because the only acceptable motivation for fishing is to fish with a harvest aim. Recently, this statement has been revised by specifying that this ban applies if the only intention of the angler was to experience joy and excitement by practicing voluntary C&R (Mattilsynet 2019). Like in the German case, this judgement is much less about what happens to the fish, but about the moral judgments of the motivations and intentions of the actors (Riepe and Arlinghaus 2014). Given the complexity of the debate, the Norwegian Food Safety Authority further recommended implementing a ban on voluntary C&R as a guideline rather than an actual fisheries regulation, although they may consider an actual change in fisheries regulations if this ban is not followed. Recently, a maximum landing size of 200 cm has been implemented for halibut requiring the release of very large individuals. However, even with this maximum landing size in place, such a C&R ban can be problematic as it can lead to unforeseen ecological consequences. Large specimens which are below the maximum landing size are often released voluntarily because they are important spawners and are not suitable as food due to the coarse meat texture and higher concentrations of environmental contaminants. Thus, if such large spawners now would have to be landed, and fishing pressure remains high, this could ultimately have negative consequences for the fish stocks and the people eating the fish. It may therefore be wise to carefully evaluate the necessity and consequences of voluntary C&R regulations before their implementation because policies driven by individual-level welfare considerations may bring about important population-level conservation problems related to overfishing due to overharvest.

19.5 The Future of Recreational Fishing in the Light of Fish Welfare Concerns

Angling and other recreational fishing practices inevitably have some negative impacts on fish welfare, e.g. by causing stress and injury to the individual fish, and we have shown that many of these issues can be reduced practically by altering fishers' behaviour and practices. Yet, as our case studies have shown, ultimately, the question of whether recreational fishing practices are morally acceptable from a

welfare perspective may depend on the intention of the actor (Olson 2003), and human values and standpoints (Riepe and Arlinghaus 2014), which cannot be answered by natural sciences. However, natural sciences can contribute to promote fish welfare by studying welfare indicators, which can serve as a basis to improve fish welfare in recreational fisheries. Moreover, such studies can serve as a basis to evaluate the welfare impacts of angling and angling practices such as C&R and weigh those impacts against other human interests (Arlinghaus et al. 2007b).

That said, as our case studies have shown, the issue of fish welfare quickly extends into the moral domain by relating to ethically acceptable or unacceptable intentions of recreational fishers. In this context, the most visible welfare debate centres around voluntary C&R, which is considered ethically problematic in some countries if the actor fishes without the basic intention to harvest, while the very same practice is seen as the desired solution to minimize fishing impacts in other cultures (e.g. USA, Canada, UK). In recent years, the moral debate in recreational fishing, and fishing in general, has extended to question whether fishing for food is acceptable (Bovenkerk and Braithwaite 2016). Such development could, in turn, lead to voluntary C&R becoming a morally superior practice to catch-and-kill, again based on ethical welfare arguments. Alternatively, morally questioning whether killing of fish is acceptable could be equated with limitations on recreational fishing, if the only purpose of recreational fishing considered appropriate is to fish for personal consumption. As these examples are showing, dealing with fish welfare becomes complicated the moment one moves beyond the simple applied biological question of how to minimize fish welfare impacts.

Dawkins (2017) advised that fish welfare can be improved without referring to contentious topics such as consciousness or suffering. Similar arguments have been suggested in the context of recreational fishing (Arlinghaus et al. 2007b; Browman et al. 2019). We have shown that much effort has been made to minimize negative welfare impacts on the individual fish by developing best practice guidelines (EIFAC 2008; FAO 2012), but a lot of further improvement can be achieved at the species-specific level (Cooke and Suski 2005). However, if one considers the moral judgement of a recreational fishing practice solely in terms of the intention of the actor (e.g. whether you fish for harvest or not), the ethical judgement of, and recommendations for, the activity may be divorced from the biological underpinning of fish welfare. In other words, merely judging the ethical appropriateness of recreational fishing in terms of morally acceptable intentions of the angler may unintentionally undermine fish welfare, as less attention is given to what actually happens to the fish. We suggest avoiding grand moral reasoning and instead using science to promote changes practices and fishers' behaviours in a way that minimizes or avoids fish welfare impacts in recreational fisheries. Our work presents concrete steps into that direction.

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