Fisheries Research 204 (2018) 348–360

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

"Nature's Little Helpers": A benefits approach to voluntary cultivation of hatchery fish to support wild Atlantic salmon (*Salmo salar*) populations in Norway, Wales, and Germany

Hannah L. Harrison[a,*], Sophia Kochalski[b], Robert Arlinghaus[b,d], Øystein Aas[a,c]

[a] Norwegian University of Life Sciences (NMBU), Faculty of Environmental Sciences and Natural Resource Management (MINA), Universitetstunet 3, 1430, Ås, Norway
[b] Department of Biology and Ecology of Fishes, Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), Müggelseedamm 310, 12587, Berlin, Germany
[c] Norwegian Institute for Nature Research (NINA), Vormstuguvegen 40, NO-2624, Lillehammer, Norway
[d] Division of Integrative Fisheries Management, Faculty of Life Sciences and Integrative Research Institute on Transformations of Human-Environment Systems (IRI THESys) Humboldt-Universität zu Berlin, Unter den Linden 6, 10099, Berlin, Germany

ARTICLE INFO

Handled by George A. Rose.

Keywords:
Salmonids
Salmonidae
Hatcheries
Conflict
Recreational benefits
Community resource management

ABSTRACT

Voluntary hatcheries, or hatcheries operated privately by local anglers and fishery owners, are a historical part of salmonid conservation and enhancement efforts in Europe. However, these types of hatcheries have faced increasing scrutiny over the last several decades because of the potential negative ecological impacts created by stocking salmon into wild (albeit declining) populations. We hypothesized that hatchery programs provide value to communities well beyond the possible conservation contribution to local salmon. Utilizing a qualitative ethnographic approach, we identified and classified a range of benefits produced by voluntary salmon hatcheries within three case studies in Norway, Wales, and Germany. Across all cases, voluntary hatcheries facilitated or provided diverse social, psychological, and conservation benefits to individuals and groups of cultivators, as well as to the river environment. Voluntary hatcheries can be considered as a visible means of environmental stewardship and are perceived by many operators as an important means for mitigating human obstacles to wild salmon conservation. Based on the multiple benefits that voluntary hatcheries create for the people engaged in hatchery activities, we lay out alternative views that add to the traditionally black-and-white, pro or anti-hatchery perspectives. Improved incorporation of multiple social-psychological hatchery benefits into future fisheries management decisions, outreach, and communication will provide a more holistic approach to sustainable hatchery management, reduce stakeholder conflict, foster civil engagement in salmon conservation, and enhance environmental stewardship.

1. Introduction

Stocking is a much used and abused management tool in fisheries management and conservation world-wide (Cowx, 1994). Stocking objectives range from improving fishing opportunities to purely conservation-oriented stocking activities designed to protect and enhance small or declining populations (Arlinghaus et al., 2016; Lorenzen et al., 2012). Though stocking of salmonids (*Salmonidae*) has historically been a widespread, popular management initiative among many stakeholder groups to improve ("cultivate") wild stocks (Berg, 1986; Bottom, 1997; Wolter, 2015), improvements in scientific understanding of potential negative impacts of cultivation on wild salmonid populations (Bolstad et al., 2017; Glover et al., 2017) have challenged the scientific and managerial opinion in relation to stocking (Arlinghaus et al., 2015; Lorenzen et al., 2012; Sandström, 2011). Stocking can produce significant benefits to fisheries and help restore and conserve fish populations (Lorenzen et al., 2012). Although a range of contextual factors affect the outlook of stocking programs, in many situations alternative tools to stocking may prove superior in protecting and enhancing threatened fish stocks (Arlinghaus et al., 2016). However, stocking where hatchery fish are released into naturally recruiting populations can produce significant conservation concerns. Stocking has been documented to spread disease (Hewlett et al., 2009), affect local genetic integrity through population mixing (Laikre et al., 2010), reduce population growth of wild stocks (Chilcote et al., 2011), and contribute to the challenges faced by the wild stock component in anthropogenically altered rivers (Buoro et al., 2016; Laikre et al., 2010; Lorenzen et al., 2012).

* Corresponding author at: Norwegian University of Life Sciences, MINA, P.O. Box 5003, NO-1432, Ås, Norway.
E-mail addresses: hannah.lee.harrison@nmbu.no (H.L. Harrison), kochalski@igb-berlin.de (S. Kochalski), arlinghaus@ibg-berlin.de (R. Arlinghaus), oystein.aas@nina.no (Ø. Aas).

https://doi.org/10.1016/j.fishres.2018.02.022
Received 24 September 2017; Received in revised form 22 February 2018; Accepted 23 February 2018

Over the past 30–40 years, science has become increasingly critical toward stocking in light of unavoidable trade-offs between yield increase, cost, and potential negative impacts on wild stocks (Amoroso et al., 2017; Camp et al., 2017). As a result, in places where wild salmon populations still exist, stocking programs are increasingly being restricted (e.g., Norway) or ended (e.g., Wales) in a managerial preference to strengthen wild stocks through habitat restoration initiatives. Meanwhile, in places where salmon have gone extinct (e.g., Germany) or where populations have greatly declined (e.g., France), there is little alternative to stocking when trying to re-establish self-sustaining stocks in the wild (Granek et al., 2008). The same is true for rivers where the local salmon population has been significantly affected by parasite infection or environmental destruction (Forseth et al., 2017). In Germany, for instance, despite decades of salmon stocking no single self-sustaining salmon stock is known to the authors, suggesting that habitat limitations continue to constrain re-establishment of a stock.

Stocking governance systems differ throughout the world. In some countries such as the USA and Canada, stocking is typically conducted by state-run hatcheries. Conversely, in much of Europe fishing rights are private and tied to land ownership; here stocking decision-making is often conducted by local-level clubs and associations or by land owners (henceforth "cultivators") (Fujitani et al., 2017; Riepe et al., 2017; Stensland, 2010). In the European context, it has been commonly observed that private actors organize voluntary hatcheries designed to support, protect, and restore wild stocks of iconic, high-demand species such as Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) (Arlinghaus et al., 2015; Daedlow et al., 2011; Fujitani et al., 2017), and that these initiatives remain popular amongst cultivator groups (Riepe et al., 2017). This study focuses on what we term "voluntary hatcheries", or hatcheries operated by local angling or river owner groups for the purpose of conserving local wild Atlantic salmon stocks through stocking either in stock rebuilding or stock enhancement contexts.

Hatcheries and associated stocking programs raise three primary concerns: 1) the physiology, behavior, and overall fitness of hatchery-reared fish and how they differ from wild conspecifics (Blanchet et al., 2008; Fleming and Petersson, 2001; Jonsson and Jonsson, 2006; Swain and Riddell, 1990); 2) the effect of stocked fish on wild stock genetics through inbreeding and disease and parasite transmission (Garcia de Leaniz et al., 2007; Verspoor, 1988); and 3) a preference among many stakeholders (i.e., anglers, river owners, and local managers) for hatcheries, sometimes used as a substitute for the lack of opportunity for large-scale river rehabilitation (Arlinghaus et al., 2015; Dabrowska et al., 2014; Stensland, 2012). Salmon cultivation opponents argue that hatcheries provide a false "easy fix" to more insidious problems affecting salmon stocks, effectively detracting funding and interest from long-term conservation work (Waples, 1999). From an economic standpoint, hatchery and stocking critics also argue that stocked salmon have generally low return rates in comparison to wild cohorts (Milot et al., 2013; Romakkaniemi, 2008; Saltveit, 2006) while requiring high annual investments. Stocking advocates, meanwhile, argue that stocking programs may accelerate a population's recovery when used in tandem with habitat improvement work, and that stocking can create additive effects to increase catch in some situations (Amoroso et al., 2017). Similarly, in cases where a population verges on extinction, there is arguably no alternative to stocking due to lack of a wild stock that could produce sustainable recruits (Arlinghaus et al., 2015).

Many organizations and stakeholders are involved in the stocking controversy at multiple scales of organization, including local stakeholders, regional and state agencies, and scientific and international organizations (Sandström, 2010,2011). International policies are often bluntly critical of salmonid stocking; for example, the intergovernmental North Atlantic Salmon Conservation Organization's (NASCO) Williamsburg Resolution "is designed to minimise impacts of aquaculture, introductions, transfers and transgenics on the wild stocks" (North Atlantic Salmon Conservation Organisation, 2006). In doing so, the resolution provides guidelines to stocking, which give direct attention to the negative impact of stocking on the genetic integrity of wild stocks (North Atlantic Salmon Conservation Organisation, 2006, pg. 16–17). These and other conservation guidelines (e.g., UN Convention on Conservation of Biological Diversity North Atlantic Salmon Conservation Organisation, 2017) direct national-level fisheries managers and policy makers to develop more restrictive guidelines for country-specific stocking programs (Sandström, 2011). Meanwhile, local-level hatchery supporters try to engage in the debate by citing hatchery-supportive literature and arguments, questioning the credibility of work that showcases negative impacts of stocking, and often referencing the specific circumstances of local hatchery and stocking projects (or related problems such as escapees from aquaculture) (Brannon et al., 2004; Siemens et al., 2008). Somewhat in the middle, Waples (1999) argues that hatcheries are neither inherently good nor inherently bad, and "neither of these positions leads to productive dialogue, nor is either supported by a thoughtful consideration of the issue" (pg. 13). Yet, managers are often compelled to rely upon "best available science" (Charnley et al., 2017) in designing cultivation policies. Such science typically is ecology and biology-oriented, omitting the human dimensions (Arlinghaus et al., 2017; Ditton, 2004). This is unfortunate, as human dimensions are usually of prime importance in fisheries management success (Arlinghaus, 2006). Attention (from both managers and local stakeholders) focusing on the non-human dimensions of fisheries management (Ditton, 2004) runs the risk of ignoring important causes and drivers of conflict (Arlinghaus, 2005; Arlinghaus et al., 2017, p. 201), in cases of voluntary hatcheries and stocking in general (Riepe et al., 2017; van Poorten et al., 2011).

While the debate over hatcheries focuses primarily on the effectiveness and risks of stocking, alternative roles and benefits of stocking and hatcheries, such as the psychological and educational benefits of being involved in conservation, remain largely unexamined. In this context, voluntary cultivation of salmonids shares many similarities with outdoor recreation. Such activities are self-chosen, voluntary, and based on the individual's investment of resources such as free time, money, and knowledge/skills. A large body of literature in outdoor recreation in general, and recreational fishing in particular, has underscored that participants engaging in angling activities reap multiple types of benefits (Driver and Knopf, 1976; Fedler and Ditton, 1994; Holland and Ditton, 1992; Parkkila et al., 2010; Weithmann, 1999). These benefits enable people to meet their needs, pursue their goals, and increase their quality of life; in other words, to increase their well-being (Britton and Coulthard, 2013; Pretty et al., 2007).

The psychological, physiological, social, and economic benefits that accrue on the level of the individual also interact across scales leading to effects on society on a larger scale (social/cultural, economic, and ecological) (Driver, 2009; Manning, 1999; Parkkila et al., 2010). For example, engaging in cultivation can foster the subjective/cognitive and relational well-being of the individual while also achieving instrumental conservation benefits (by increasing or conserving salmon stocks) that benefit communities or entire human-ecological systems (Voyer et al., 2017). If participants in voluntary cultivation of salmon derive multiple benefits from the activity, the resulting individual and societal benefits potentially exceed the costs of fish cultivation and its assumed physical contribution to salmon conservation.

We posit that voluntary hatcheries produce multiple benefits at both individual and group levels that exceed the "narrow" focus on the biological contribution of hatcheries to wild salmon populations. By drawing on the multiple benefits framework from outdoor recreation research (Driver, 2009; Manning, 1999), the objective of this study is to identify and assess the full range of benefits produced by voluntary hatcheries. We then use this assessment to understand the influence of these multiple benefits on salmon management, conservation, and conflict.

2. Methods

In this study, an ethnographic approach allowed access to observe and experience the cultivator-hatchery relationship and associated benefits, including personal issues of value, relationships, and meaning assigned by individuals to their hatchery activities. Ethnography is a well-established approach to study fisheries, particularly in the small-scale fisheries literature (Carothers, 2010; Fabinyi et al., 2015; Harrison, 2013; Harrison and Loring, 2014; Loring et al., 2014). Using typical ethnographic methods such as interviewing and participant observation, the research team examined the multiple functions of hatcheries as producers of psychological, social, and conservation benefits for fishing groups and individuals within three case studies.

Data was collected through in-depth, semi-structured interviews with 15–25 individuals per country representing both voluntary hatchery groups and salmon managers in Norway, Wales, and Germany. All interview participants were identified through the key informant method (Marshall, 1996). Case studies were selected to represent a variety of hatchery programs with respect to longevity of stocking program, governance system, and current state of stocking in the area. Fisheries management in these three case studies is typical to European privately-owned recreational fisheries (Arlinghaus, 2006). Details concerning the spatial, governance, and stakeholder characteristics of each case are described in Table 1.

As part of the data collection protocol, the research team also engaged in participant observation in a variety of hatchery and fishing-related activities in Norway and Wales, spending between two to three weeks in both locations. Participant observation activities (e.g. angling, observing river conditions with anglers, conducting regular stock maintenance, and moving fish into new tanks prior to stocking) took place in a variety of locations that allowed the researchers to gain important insights into hatchery and salmon-related activities. These insights functioned as a necessary basis to, and were explored further through, the interview process.

In Norway, data collection was conducted in April and May of 2016 in Sunnmøre district, with the primary focus on the voluntary hatchery used to stock the Ørsta River. In Wales, data collection was conducted in June of 2016 within the River Wye catchment area primarily between the Builth Wells and Monmouth areas. In Germany, fieldwork was conducted between March and June of 2017 in the tributaries of the River Weser and the River Elbe, with a focus on one hatchery on the River Elbe.

Interviews typically lasted between 60 and 120 minutes and were recorded and transcribed in full. In Norway and Wales, most interviews were conducted in English, and those who preferred a non-English language were provided with a translator during the interview. Alternatively, interview participants were encouraged to express detailed comments in their native language and provide only a short summary in English. The detailed native language descriptions were then later formally translated to English and included in the transcribed interview texts. In Germany, most interviews were conducted in German, and later transcribed and translated into English. Interviews were semi-structured in nature and guided by a written set of questions and discussion prompts. The interview guide was written to elicit perspectives on several topics, including knowledge production, hatchery practices and organization, drivers for hatchery and stocking practices, benefits and consequences of hatchery work and stocking, local history of stocking, social networks within hatchery groups, causes and drivers of conflict surrounding the use of voluntary hatcheries, fisher habits and demographic information. Questions were open-ended, intended to encourage interview participants to share information and stories they found most relevant in illustrating their perspectives.

Analysis of interviews and ethnographic field notes was an iterative process conducted using Atlas.ti version 7 (*ATLAS.ti*, 1999), a qualitative analysis software. The data was first open coded for emerging themes through repeated reading and categorizing of data using software tools (Charmaz, 2014). In this context, codes are a word or phrase that are chosen to capture the essence of the concepts emerging from the text. Through the coding, concepts are being categorized and the researcher may begin to group together like concepts or ideas (Corbin and Strauss, 1990). The data was then coded a second time to explore previously identified themes and elicit insights into specific topics. A third round of analysis was conducted by writing analytic memos using the most prevalent and thematically relevant codes as memo topics. Coding and memoing are an important part of a grounded analysis of data that allows concepts to emerge and theories to develop through consistent and repeated presence in the data (Corbin and Strauss, 1990), thereby forcing the researcher to remain grounded within the text and check all developing theories against evidence from the data. Text from the memoing analysis and significant code names formed the basis of the data analysis in this article.

The data sets for each country were transcribed and coded in the sequence in which they were collected, beginning with data from the Norwegian case, then Wales, then Germany. In this, the authors were immersed several times in each interview, beginning with conducting the interview, then transcribing the interview through hours of intense listening and re-writing, then through the analysis process. Time between the original interview and the first transcriptions (2–3 months) was intentionally inserted to give the authors a fresh view of each interview before data analysis. The first author coded the Norwegian and Welsh interviews, and themes were discussed amongst the authors afterwards. The German interviews were divided and coded separately by the first and second author, and codes were then compared and discussed afterward to compare the results of each researcher's analysis. Though category labels naturally varied between individual researchers, this comparison revealed overall agreement on identification of the major concepts presented in this article. This agreement provided researchers relative certainty in the validity and rigor of their approach to data categorization and interpretation.

3. Results

We identified a range of psychological (Table 2), social (Table 3), and conservation benefits (Table 4) mentioned by interviewees as derived from their participation in hatchery and salmon stocking activities. Throughout the text, alphanumeric references relate the text to descriptions in the benefit tables ("P" refers to psychological benefits, Table 2; "S" refers to social benefits, Table 3; "C" refers to conservation benefits, Table 4). All benefits presented here were identified across all three case studies unless otherwise described.

3.1. Psychological benefits

3.1.1. Achievement, contribution, and satisfaction

Cultivators reported strong feelings of personal satisfaction resulting from their cultivation activities. Cultivators find great value in caring for and contributing to the well-being of salmon (P2), especially when releasing salmon into the wild. This satisfaction derives from two subsidiary feelings that are closely linked: achievement and contribution.

In terms of achievement, cultivators enjoy overcoming the challenges of raising a sensitive and at-risk species and, in Germany, of completing the "impossible" task of bringing back an extinct species (P4). Closely linked with this is the cultivators' perceived ability to learn new skills, adapt cultivation practices to the local environment, and successfully raise otherwise vulnerable juveniles (P3). Doing hatchery work and participating in salmon stocking is obviously deeply satisfying to cultivators and creates positive feelings of self-esteem and achievement.

In terms of contribution, cultivators feel they have a responsibility as anglers to contribute to the well-being of salmon (P4). Many cultivators enjoy being part of something "bigger than themselves", as

Table 1
Detailed descriptions of case study areas and features.

	Hatchery locations and river details	Hatchery history	Hatchery operated/stocking done by:	Hatcheries regulated by:	Guiding legal frameworks or policies affecting hatchery and stocking management (state level)	Current status of voluntary hatcheries and stocking
Norway	Ørsta River; ~25 km long; designated National Salmon River	Original hatchery was built in the late 1950′s to compensate for channelization of three kilometers of the Ørsta River; current hatchery built in 1970′s	Ørsta river owners association and Ørsta Hunting and Fishing Association (joint collaboration); average age range of cultivators: 60–80 years old.	Norwegian Environment Agency (Miljødirektoratet) makes overarching regulations; regulations interpreted, implemented, and enforced by County Governor (Fylkesmannen)	"Guidelines for stocking of Anadromous salmonids" released in 2014; guidelines focus on controlling genetic integrity of stocks	Active – annual rearing and stocking
Wales	River Wye and some tributaries; ~250 km long; forms partial border between England and Wales; designated Special Area of Conservation	Glasbury hatchery: 1974; Green Bottom Hatchery: 1995–2001; Painscastle hatchery: 2002–2008; Natural Resources Wales Cynrig hatchery (Cynrig Fish Culture Unit) 2009 on; Semi-natural rearing ponds were started in 2012 in conjunction with Natural Resources Wales hatchery	Various groups over the years; Wye Salmon Fishery Owners Association; Wye and Usk Foundation; Natural Resources Wales; Welsh Water Authority, Central Electricity Generating Board; average age range of cultivators: 50–80 years old; average age of managers and conservation groups: 40–65 years old.	Natural Resources Wales; historically hatcheries were managed by predecessor public bodies including Environment Agency Wales, National Rivers Authority, and Welsh Water Authority.	European Union's Habitats Directive (92/43/EEC); Salmon & Freshwater Fisheries Act 1975; Live Fish Movement Regulations.	Closed in 2014; last parr released from semi-natural rearing ponds in 2015; Cynrig, the only remaining hatchery operated by Natural Resources Wales maintained as research facility.
Germany	River Stepenitz, ~84 km long tributary to the River Elbe; designated Special Area of Conservation, designated nature reserve within Germany's Federal Nature Conservation Act and one of three project water bodies for the reintroduction of Atlantic salmon in the Federal State of Brandenburg	Stocking in the tributaries started in 1999 inspired by improved water quality in the River Elbe and by other German salmon stocking programs. Hatchery has worked with own returning salmon since 2013	Fario fly fishing club in Berlin; most members 40–60 years old; hatchery operated in cooperation with Institute of Inland Fisheries Potsdam-Sacrow (IfB) (scientific monitoring) and the FederalState's fishing association (financing)	Federal State's law	European Union's Habitats Directive (92/43/EEC); Veterinary regulations for the hatchery; Fishing laws for catching of broodstock	Active – annual rearing and stocking

Table 2
Psychological benefits derived from voluntary hatchery activities.

Benefits derived from cultivation work	Norway	Wales	Germany	Example activity/quote
P1: Personal Identity	Cultivators associate personal and cultural identities (i.e., "being Norwegian") with salmon and salmon-related activities; work within the hatchery allows a tangible relationship with salmon, strengthening the relationship between anglers/river owners and salmon as a part of personal identity;		Norwegian and Welsh cultivators and anglers identify as "salmon people", but not the Germans; all cases value volunteering and to "look beyond the end of my nose".	*"Everyone has a relation to salmon because salmon, that's Norway. Atlantic salmon, that's Norway. Every Norwegian [has] a relation to salmon I think. Yes.* " [sic throughout]
P2: Empathy/caring for salmon	Cultivators enjoy witnessing and facilitating the salmon life cycle and caring for juvenile fish; meaningful when done with family members; opportunity for parents to teach skills to children;	Cultivators in all cases enjoyed witnessing and facilitating the salmon life cycle, particularly during captive stages in semi-natural rearing ponds	Same as other cases, additionally they enjoy tangible interactions with salmon; opportunity to "close" the currently incomplete life cycle	*"We love these fish and we want the fish to be in the river. We are very happy when we see a fish coming back to the river, and we can help the river to reproduce."*
P3: Learning or fascination	Facilitated by the hatchery setting, cultivators have opportunity to closely interact with a species that provides fascination and awe; cultivators have learned new skill sets to cultivate high quality fish, and in most cases are interested to continue learning and improving their cultivation skills			Example: cultivators have learned electro-fishing and other skills to improve their cultivation practices
P4: Feeling of contribution (sense of purpose/achievement/ self-esteem/life satisfaction)	Cultivators feel a responsibility to care for nature and perceive the decline of salmon as something they should work to resolve; hatcheries provide opportunities to do this using existing skill sets;	Cultivators feel responsibility as river owners and as anglers to actively maintain the stock, but lack opportunities to do so; loss of hatchery activities is a loss of opportunity to participate in the well-being of salmon	Cultivators feel they contribute to bringing salmon back to Germany; they believe if they did not do this work, the salmon stock would decline and disappear; they enjoy the achievable challenge of rearing salmon; they agree that conservation work improves the reputation of anglers in Germany	*"I think people get a lot of different things from [hatchery work]. Some of them I'm sure feel they want to give something back."*
P5: Nature ethic/spiritual	Cultivators develop and reinforce feelings of respect, wonder, awe, and experiences of humility and connectedness to salmon through hatchery activities; some relate spiritually to "helping God" by rearing fish	Cultivators experience wonder and awe while caring for juvenile salmon; cultivation activities are linked closely to the wellbeing of the riverine environment, providing a sense of connectedness	Strong perception that what is good for salmon is good for all animals; belief that it is inherently good to have salmon living in the rivers, even if not fishable	*"When everything is natural, you thank God that it works. But as an old [angler] told me, "why don't we help God a little? He's a busy man. He just can't fix everything. We can give him a hand sometimes."*
P6: Hobby (incorporates relaxation, getting away, physical activity, stress reduction)	Middle and late-aged cultivators regard having a meaningful, active hobby as an important part of later life; they derive relaxation and connection to others through hatchery activities	Cultivators enjoy engaging in conservation activities that support their hobbies; thus, hatchery work has become an enjoyable hobby as well	Cultivation is tied to fly fishing as a hobby and to a laborious activity; anglers enjoy and look forward to many of the activities associated with the hatchery;	*"It's become a hobby. And a big interest. Yeah, 'cause it's not so fun to have a [hatchery]. It's a lot of work. Many, many hundred [hours] a year. So it's not [just] for fun. But I think it's for fun. [A man] gets away from his life for some time."*
P7: Routine	Hatchery work forms an important part of the daily/weekly/seasonal routine for those involved in hatchery activities	Time spent at hatchery and semi-natural rearing ponds provides an opportunity to escape from normal routine	Cultivators look forward to hatchery work at the end of each fishing season; the fishing and cultivation "seasons" complement each other in an annual cycle of fish-related work;	Example: cultivators look forward to visiting and caring for the growing salmon each day or each week, as well as attending regular meetings held at the hatchery

Table 3
Social benefits derived from voluntary hatchery activities.

Benefits derived from cultivation work	Norway	Wales	Germany	Example activity/quote
S1: Inter-generational local ecological knowledge transfer via teaching/ experience (includes activities specifically with family members)	Cultivators value the opportunity to pass salmon and cultivation knowledge to younger generations; conservation work is important recruitment strategy to bring young people into angling and cultivation work	Cultivators possess rich knowledge of river conditions, ecological history, and salmon; hatchery groups regularly visited schools, hosted courses teaching salmon ecology, biology, angling skills;	Have in-depth knowledge of local riverine environments; pass knowledge on to younger or new anglers; learn from salmon hatcheries of the same type in other river systems and countries and share knowledge between groups;	*"Sometimes I learn something from them and the next day they are asking me something and I [teach] something to them. Most of the olders are very kind. They also appreciate the younger generation are coming up and see what they are doing and learning by what they have done, these last centuries. It's quite interesting."* [sic throughout]
S2: Social interaction with peers/people with similar interests	Enjoy social interactions with peers organized around hatchery activities and using the hatchery as a meeting place; social interactions are important to quality of life and supporting conservation work;	Opportunities to interact with peers through hatchery activities are important to late-aged men; Social networks support organization of conservation work	Cultivators enjoy spending time with other people of similar values and interests; many anglers join club to participate in conservation activities;	*"But the sense of community and everything else that they develop with those little hatcheries… okay, it's mainly older guys and stuff like that, but it's like a social club. And some of these are quite poor communities so that is really an incredible benefit to that place."*
S3: Opportunities to network with people outside of normal social groups	–	Cultivators enjoy meeting people with similar interests from outside their regular social groups; networking allows information and cultivation technique exchange between geographic areas	Hatcheries facilitate opportunities for cultivators to meet people from different backgrounds and livelihoods with shared interest in cultivating salmon; cultivators enjoy finding "community" amongst other anglers	Example: anglers come from long distances, take time away from work to participate in hatchery tasks; anglers meet others who share common interests; interaction facilitates building of angler and conservation networks
S4: Historical/heritage Value	Fishers perceive salmon cultivation as an important part of Norwegian history, culture; they are inspired by past abundance to cultivate for the future	Salmon are an important part or angling legacy, reputation; river would be "less" without the presence of salmon; inspired/ motivated by past abundance of stocks	Cultivators are inspired by salmon stocks of the past feel loss and desire to restore salmon as legacy for children and as part of national legacy	Example: many hatcheries have historical photos that show the height of the fishery; cultivators link their present-day activities to a tradition of cultivation work
S5: Community identity	Cultivators identify as part of an angling, river owner, and cultivation community;	Community identity was previously supported by hatchery activities; absence has fractured club and personal relationships	Cultivators perform outreach activities to raise awareness about heritage value of salmon; they encourage "ownership" by locals of reintroduced salmon	Example: cultivators wish to bring their surrounding communities into contact with the hatchery through outreach activities

Table 4
Conservation benefits derived from voluntary hatchery activities.

Benefits derived from cultivation work	Norway	Wales	Germany	Example activities
C1: Participation and interest in conservation activities	Hatcheries facilitate interest in conservation activities; cultivators act as lobbyists for health of the river system and habitat improvement in addition to stocking; cultivators act as sentries to problems in the river, especially escaped farmed salmon	Prior to closure, cultivators formed a cross-section of other interest groups who organized and enacted conservation work; hatcheries offer low barriers to entry to participate in salmon conservation	Cultivators perceive habitat improvement measure as essential and complementary to hatcheries; they lobby for habitat improvement on multiple scales, and do habitat improvement activities; hatcheries incentivize better stock monitoring; cultivators are first to identify and act on environmental threats	Example activities: bank clearing and maintenance; invasive species monitoring and removal; litter cleanup; habitat improvement projects; flushing out sediment buildups; creating new spawning habitats
C2: Builds trust and likelihood of collaboration between cultivation groups and managers/policy makers	Hatcheries regulations facilitate regular communication between cultivators and managers; all stakeholder groups value open lines of communication about hatchery management and stocking; this discourse has fostered a willingness to collaborate on non-hatchery conservation initiatives	Termination of the stocking efficacy study created a breach of trust between cultivators and management authorities; cultivators report little trust for fisheries policy makers and managers, view the management process as politicized, unwelcoming to angler perspectives	Cultivators have tenuous relationships with local, regional governments based on managerial interest in cultivation projects; cultivators want more interest at the state level (and downward) to do studies on stocking outcomes; hatchery work creates political interest and gives starting point and incentive to politicians, managers to address river conditions	Example: cultivators have better working relationships with managers who support hatchery activities, allow cultivators to adapt regulations to local conditions; cultivators participate in policy consultations and want to work with managers to achieve conservation goals
C3: Facilitates partnerships to support conservation work (i.e. fundraising; invasive species control; conservation science)	Cultivators have relationships with local aquaculture companies to communicate about escaped farmed fish, and build relationships that support hatchery expenses; cultivators rear brown trout for hydropower compensatory stocking; cultivators want to develop scientific partnerships to further salmon research	In the absence of the hatcheries, new groups have formed to advocate for strategic use of hatcheries, predator control, shared use of the river, scientific studies on salmon, etc.; conflict over the termination of stocking led to dissolution of some long-standing groups	Cultivators develop partnerships with other angling associations and scientific institutions, domestic and international, to support monitoring, stocking, and hatchery operations; they have strong interest in science and believe cooperation between angling groups and scientists is essential for the hatcheries to succeed in the long run, both in terms of the labor and financing involved and the support for hatcheries in general	Example (Norway): cultivators work with a local aquaculture facility to monitor and remove any escaped farmed fish, and receive advice and some material support in operating the hatchery
C4: Biodiversity support	The hatchery provides a location for compensatory brown trout rearing (for hydropower facility); cultivators see salmon as keystone species; believe what is good for salmon is generally good for the river ecosystem	Remaining hatchery is used as research and biodiversity enhancement facility by government agencies; anglers express concern about other species in the river seeing similar decline as salmon	Salmon viewed as flagship species – its conservation greatly benefits other species; hatcheries used for sea trout and brown trout; cultivators consider hatcheries as potential conservation tools for other species	Example activities: hatcheries can be used to produce threatened species (e.g. freshwater pearl mussel, white-clawed crayfish) in the same facility as salmon, potentially with symbiotic benefits
C5: Risk reduction by retaining knowledge/skill ("insurance policy")	Cultivators strongly believe hatcheries provide an "insurance policy" against environmental or anthropogenic disaster; hatcheries provide a repository of cultivator skill and knowledge acquired through years of learning by doing, cooperation with other groups, and formal education	Cultivators and managers believe that hatcheries provide an "insurance policy" against environmental or anthropogenic disaster; cultivator groups hold a repository of skill and knowledge for local salmon cultivation, but without opportunities to practice and transmit knowledge, may lose these qualities	Hatcheries are now developing self-sustaining and locally adapted stocks, acting as inventory to a growing population; they are occasionally viewed as insurance policy for environmental disaster and act as repositories for knowledge cooperation with other groups and formal education;	Example (Norway): gene banks are used to store the genetic material for salmon runs threatened by disease (e.g. *gyrodactylus*); cultivators view voluntary hatcheries as institutions, for storing knowledge and skill (and potentially genetic material) in the same manner as the nationally operated gene bank program

described by one Norwegian cultivator:

> *"When everything is natural, you thank God that it works. But as an old [angler] told me, 'Why don't we help God a little? He's a busy man. He just can't fix everything. We can give him a hand sometimes."' (Participant #20, Norway)*

In Norway and Wales, hatchery projects have few, if any, clearly defined or quantifiable stocking goals beyond 'improved' stocks and the upper limits of allowable stocked material. Instead, most cultivators desire to restore salmon stocks to their "glory days", while others aimed at maintaining current salmon populations as well as achieving benefits for other aquatic species and the ecosystem. Similarly, conservation project timelines are a critical issue, as some cultivators anticipate the restoration of salmon stocks will likely come too far in the future for them to personally enjoy it. While many see the "journey as the reward", others concluded that hatchery work was necessary to speed up the process of salmon restoration. Notably, cultivators in Germany tended to have defined stocking goals with specific timelines or other metrics, but these goals varied amongst individual cultivators within the same hatchery project.

For many cultivators, hatchery work supports a nature ethic based around care for and interaction with nature (P5) and a philosophy of responsibility to engage in work that will benefit the natural world. Many cultivators consider the hatchery to be a symbol of this ethic, and the cultivation work an act of ethical fulfillment. Nearly all cultivators indicated strongly that their motivation to do cultivation work is primarily to give back to nature and a belief that conservation work is a good thing to do, both for people and for salmon. As exemplified by the chairman of one German angling club:

> *"We wanted to do more than a normal angling club. To put it this way, we wanted to give something back [to] nature. As a user of nature, one takes from nature, destroys nature, and that was a bit the original idea, to give something back to nature." (Participant #5, Germany)*

3.1.2. Hobby and leisure time

In all three cases, cultivators desire to do conservation work that matches both their personal interests (i.e., salmon and angling) and utilizes pre-existing skills and knowledge sets. In all cases, hatchery work is perceived as meaningful and highly enjoyable, and many cultivators categorized their hatchery work as an important "hobby" or leisure activity (P6). Dependent on the time of the year, some of the cultivators spend a significant amount of time (often 1 + hours per day) in the hatchery doing cultivation-related work. Interestingly, many cultivators also spent unstructured free time in the hatchery when no work was required (P6), a behavior related to fascination, awe, and desire to interact frequently with salmon (P3). Another reason for frequent hatchery visits is the social factor, as many groups host regular social meetings in the hatchery (P2). As explained by a Norwegian cultivator:

> *"I think that's the most important thing and why people are willing to do it. It's social. We meet often every Friday in the hatchery and have a chat and spending time [sic]… we have a house by the river here. It's very nice. Sit there and watching the fish in the summer… so it's, of course, social. That's a really important [thing] when you're going to use so much of the free time." (Participant #4, Norway)*

Hatcheries also fulfill an annual cycle of salmon activity for cultivators (P7). For approximately half the year, cultivators fill their free time with angling. When the angling season ends, cultivators fill time once spent angling with hatchery work. For many, this transition from angling to cultivation also achieves a transition from extraction from the salmon resource to contribution. The satisfaction achieved by this pairing of activities relates strongly to the nature ethics held by cultivators (P5), as well as their desire to see a sustainable salmon resource (P4).

3.1.3. Personal identity

The personal identity of cultivators is strongly linked to and supported by their involvement in hatchery work (P1). Cultivators experience feelings of independence and self-determination while doing fish cultivation as the work grants an ability to act in a semi-independent manner alongside like-minded people. Some cultivators even said they would be "lost" without the hatchery as part of their weekly routine. Being a volunteer, a salmon person, capable craftsmen in charge of the hatchery operations, or a respected member of the club's board forms an important part of cultivator's positive self-perception. In some cases, cultivators related not only personal identities to their relationships with salmon cultivation, but also their national identities. As one fisher described:

> *"Everyone has a relation to salmon because salmon, that's Norway. Atlantic salmon, that's Norway… every Norwegian [has] a relation to salmon I think. Yes. I remember when I was a small boy, once in a while a small piece of salmon [to eat]. It was heaven." (Participant #11, Norway)*

3.2. Social benefits

3.2.1. Facilitation of social relationships

Hatcheries are important social outlets, particularly for middle to late-aged, male anglers (S2). Hatcheries provide cultivators with ways to enjoy time with peers who have similar interests through activities they find mutually meaningful and fulfilling. Similarly, the value of volunteerism and engaging in community stewardship through hatchery activities was perceived as important by many interviewees. Based on these shared values, some hatchery groups have developed a strong feeling of community (S5). Said one Norwegian cultivator:

> *"So a hatchery is [a] very positive way of having [a] good environment locally. All people interest[ed] in the river, they meet, they have a little cigarette and talk about the river. They agree tomorrow, we do this. Yeah, so it's important. It's a club feeling." [sic throughout] (Participant #5, Norway)*

The social aspect is also important to younger cultivators, who enjoy spending time with and learning from the older members of the hatchery community (S1). Time spent with multiple generations of anglers is an important prerequisite for the transfer of knowledge, valued tradition to the oldest members of hatchery groups. Intergenerational activities also support the recruitment of new individuals into fishing and cultivation activities. Cultivators argue that hatcheries provide opportunities for young people to take part in traditional (or heritage) activities related to an iconic species, since some hatchery practices span over 50 years (S4). In all three case studies, cultivators are inspired by historical cultivation activities and expressed the desire to maintain or restore historic salmon populations for the benefit of future generations.

3.2.2. Networking

Hatcheries act as facilitators of social network development by bringing together individuals who might otherwise not interact through activities such as broodstock collection, stocking, and fin clipping, all of which demand significant labor. Leaders of some angling groups reported that work done in hatcheries helps spread awareness and support for other activities, such as teaching fishing skills to children and adults, visits to or by schools to hatcheries to teach conservation and ecosystem sciences, or activities such as litter cleanups and riverbank maintenance – all activities that additionally provide direct conservation benefits in addition to social value. Cultivators enjoy meeting new people from outside their regular social networks and making social connections related to angling and other recreational activities. As one German cultivator described:

"What is typical for our club is that many people got to know each other well. The club consists of very different groups of people, so let's say from the lawyer to the craftsman, and somehow everybody has this common topic that connects them, and there are no barriers, no barriers at all." [sic throughout] (Participant #6, Germany)

Opportunities to cultivate also build trust and working relationships between cultivation groups (and, by extension, anglers and river owners) and fisheries scientists and management officials (C2). Cultivators in all cases expressed concerns about a lack of support for hatcheries from fisheries managers and policy makers. In cases where managers, policy makers, or scientists included hatcheries in conservation schemes, however, cultivators responded with increased trust and interest in cooperation (C3). In Germany, cultivators wished for more support from the government and see the possibility of raising public interest in rivers through hatcheries. In Norway, cultivators and managers expressed that though they may disagree about the use of voluntary hatcheries in salmon conservation, successful salmon management requires working together to find common ground and mutually support worthwhile conservation efforts. A Welsh biologist echoed these sentiments:

"*I've seen a lot of my fisheries management colleagues hated by anglers, [and] who hate the anglers with a similar passion, and yet we've always had a fantastic relationship with them. I mean, okay, partly that's because they see hatcheries as a great thing because they're putting fish in the wild. But it's partly because we recognize the value of giving these guys some ownership of some part of the river. Of something that they can take care of themselves, have pride in, learn from and… have a passion for the other things about the environment. Conservation, that's really important." (Participant #15, Wales)*

3.3. Conservation benefits

3.3.1. Facilitation of conservation work

Voluntary hatcheries provide opportunities for cultivators to participate in conservation activities due to a low barrier-to-entry compared to that of habitat improvement projects, which can be expensive and require overcoming substantial legal requirements (C1). Participation in hatchery and stocking activities also contributed to cultivator's interest, support, and engagement in other types of conservation work otherwise unrelated to stocking. For example, Welsh volunteers organize litter cleanups and teach school children about ecosystem science and salmon fishing as part of their seasonal conservation work.

Cultivators participate in a variety of conservation activities as a direct result of interest, skills, or social networks developed through involvement with the hatchery. Across cases, these activities include the creation and improvement of spawning habitats and the removal of barriers for migration. For example, cultivators in Norway evaluate stocking efforts through annual autumn assessments. Similarly, cultivators in Norway and Wales reported catching and removing escaped farmed salmon while conducting broodstock collection. In some German rivers, cultivators also reported catching an increasing number of farmed salmon in the past five to ten years, and are working to inhibit their reproduction.

Hatchery activities have led cultivators to develop relationships with scientific, conservation, and (in some cases) aquaculture interests to generate financial, intellectual, and material support for hatchery work. For instance, cultivators are deeply interested in scientific research surrounding conservation and restoration techniques for salmon stocks. In all cases, cultivators discussed their efforts to incorporate best management practices into their hatchery operations, and expressed interest in participating in scientific studies focused on their local fish populations. Cultivators also exhibited long-term efforts to learn cultivation techniques recommended by scientific literature and develop working relationships with researchers.

3.3.2. Biodiversity and mitigating future disaster

Cultivators believe voluntary hatcheries provide support to biodiversity initiatives and scientific research on wild Atlantic salmon (C4). In both Norway and Germany, voluntary hatcheries raise brown or sea trout alongside salmon, while in Wales the remaining hatchery (now used only for research purposes) is used to grow indigenous, critically endangered species (e.g., freshwater pearl mussel (*Margaritifera margaritifera*)). Cultivators point out that the skill and knowledge used to grow salmon in voluntary hatcheries could also be used to support restoration or conservation work for other species, an added conservation benefit especially in rural areas where no other such facilities exist. In Germany, cultivators have adopted the biodiversity mindset into their long-term hatchery goals with some groups using hatcheries to cultivate other threatened fish species.

Cultivators and some fisheries managers view hatcheries as repositories of cultivation skill and knowledge, held collectively within the cultivators themselves and supported, developed, and transferred through their social interactions. As one fisheries manager said when describing the remaining cultivation facility on the River Wye:

"The other point is retaining capacity and competence. The husbandry of salmonids would be an important skill competence… so we're maintaining that [hatchery] [for] rearing of salmon for investigation purposes. And we believe that retaining that capacity and competence is important." (Participant # 17, Wales)

This knowledge and skill base, along with the physical capacity of the hatchery itself, act as an "insurance policy" that could mitigate against future ecological or anthropogenic disaster within the targeted salmon stock or river ecosystem (C5). In Norway, for instance, cultivators fear that incidences of escaped farmed salmon will only increase as the commercial aquaculture industry grows, and voluntary hatcheries will play an important role in magnifying wild stock genetics in the midst of farmed interlopers. Similarly, disease outbreaks are considered to be a serious threat to vulnerable salmon stocks and voluntary hatcheries-turned-gene banks could be used to mitigate the consequences.

4. Discussion

This study revealed a rich bundle of benefits produced by voluntary hatcheries that exceed their biological contributions to wild salmon conservation and fisheries. In our three cases, voluntary hatcheries provided or facilitated many of the psychological (Table 2), social (Table 3), and conservation (Table 4) benefit domains described within the outdoor recreation research literature (Freudenberg and Arlinghaus, 2009; Haas et al., 1980; Manning, 1999), with notable parallels to non-catch benefits produced by recreational angling opportunities (Arlinghaus and Mehner, 2004; Ditton, 2004; Fedler and Ditton, 1994; Manfredo et al., 1996; Weithmann, 1999). All three benefit domains were identified across all cases, though specific benefits within each domain were produced through different mechanisms and to varying degrees between cases, and not all benefits arose in every case. For example, all three cases had strong representation of social benefits (Table 3), but in Norway the benefit of *networking opportunities* (S3, Table 3) did not emerge as strongly as in the Welsh and German cases. This is likely caused by the small river size and relative isolation of each cultivation group in the Norwegian case, resulting in minimal opportunities to build social networks.

Across all three cases, the most significant benefit produced by voluntary hatcheries was as a means of participating in salmon conservation. While cultivators' interest in conservation through stocking fits in line with the history of stocking (Bate, 2001; Cowx et al., 2010; Granek et al., 2008), the use of hatcheries in enacting environmental stewardship runs counter to common perceptions that angler-driven stocking efforts are motivated primarily to improve catch opportunities through a technological fix ("techno-arrogance" (Meffe, 1992).

Enhancing opportunities for angling was either not relevant (such as in Germany), or took a seemingly secondary role in motivating hatchery work. Survey research among German fishery managers in angling clubs revealed that helping to conserve threatened species is a major motivator and driver of local management actions, including stocking (Arlinghaus et al., 2015; Riepe et al., 2017).

Another key benefit facilitated by voluntary hatcheries was engaging cultivators to support non-hatchery-related management and conservation by generating the networks, resources, and the human capital necessary to engage in small or large-scale conservation activities, such as stock monitoring, removal of escaped farmed salmon, and habitat improvement (Granek et al., 2008). Importantly, these examples of participation in conservation are distinct from work done by state hatchery programs (common to Norway and formerly to Wales, and to salmonid stocking in North America), as state programs do not typically offer opportunities for the lay public to take part in hatchery work (von Lindern and Mosler, 2014).

4.1. Examining hatchery-related benefits through frameworks for understanding benefits of outdoor recreation

Our findings suggest that the outdoor recreation framework (Manning, 1999) is suitable as a means to identify most of the benefits associated with voluntary hatcheries, though, some challenges have arisen in categorizing and describing benefits. For instance, the *routine* (P7) benefit is typically described in the literature as the opportunity to escape from daily routine by engaging in a recreational activity (Manning, 1999). While this definition remained true in the German and Welsh case, Norwegian cultivators described their hatchery activities as an important part of their normal routine as opposed to escape, and described being "lost" if their hatchery were closed and their hatchery routine interrupted. This example demonstrates that the definitions of some categories must be flexible to remain relevant in the hatchery context.

Most importantly, the way hatchery benefits were elicited through the ethnographic approach showed the way benefits were coupled and interrelated, demonstrating interdependency between benefit domains required for the production of each individual benefit (Fig. 1). For example, *routine* (P7) occurred as a function of the social nature of hatchery work as well as the fulfilling nature of participating in conservation. In another example, *networking opportunities* between cultivators (S3) provided satisfaction at the individual psychological level while simultaneously tied to shared conservation interests in cultivator groups. Social and psychological benefits shared significant overlap (S1, S2, P6), as did psychological and conservation benefits (P5, P4, C5), and to a lesser degree, social and conservation benefits (C2, C3). These overlaps not only present challenges in categorizing benefits, but importantly reflect the realities found in our case studies: psychological, social, and conservation benefits are interdependent upon one another, and each domain facilitates or enhances the production of the others. If one of the domains is threatened (e.g. if hatchery work as the catalyst for group activities is eliminated), the other benefit domains are also reduced.

The provision or secession of psychological and social benefits through hatcheries should be of interest to fisheries managers because they affect the cultivators' well-being, a strong contributor to behavior of humans in general (Hunt, 2005). Well-being is a multi-dimensional concept defined as "a state… where human needs are met, where one can act meaningfully to pursue one's goals and where one enjoys a satisfactory quality of life" (McGregor, 2008). Recreational outdoor activities can, for example, contribute to people's subjective well-being by increasing their self-esteem and improving their mood (Pretty et al., 2007). As with the benefits categories, relational and social well-being are closely interlinked and interdependent (Coulthard et al., 2011). In the present study, voluntary hatchery work was a way of both being with others (social benefits) and pursuing meaningful goals (psychological benefits), both contributing to individual and social well-being.

Hatcheries also produced specific conservation benefits (Table 4) and supported conservation as a secondary outcome of the production of psychological and social benefits. These interdependencies raise some interesting questions about the nature and substitutability of voluntary hatchery work, particularly to the relevance of "recreational" as

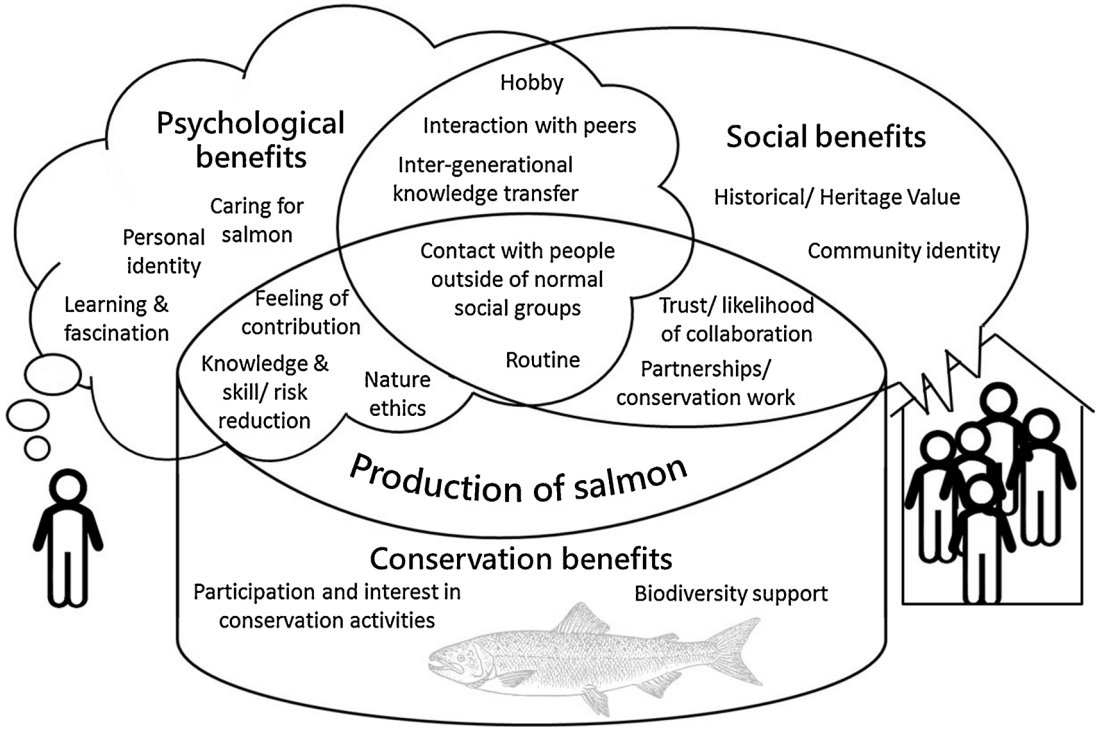

Fig. 1. Illustration of the interconnected and overlapping nature of psychological, social, and conservation benefits produced by voluntary hatcheries. Some benefits are interdependent on multiple functions and interactions occurring within hatcheries, and could not occur without the co-production of multiple benefit domains at once.

a descriptor of voluntary hatchery activities. For example, is voluntary cultivation simply another broad form of outdoor recreation focused on fish and fishing? Or, does this work belong in a category of activity more akin to traditional non-government organization conservation work, such as habitat improvement, monitoring, or activism?

These questions are relevant as voices critical of voluntary hatcheries often suggest that benefits gained from hatcheries could be substituted with a different recreational activity or a more "appropriate" conservation activity. From our study, we know that cultivators seek hatchery activities *in addition* to their regular recreation activities (e.g., angling), suggesting that cultivation work fulfills different needs or provides different or supplementary benefits than those already obtained elsewhere. Additionally, the primary benefit of "access to conservation opportunities" described above is not a benefit typically identified as part of the outdoor recreation framework in general or angling specifically, and therefore is not truly "recreational" in nature.

From this, we conclude that voluntary hatchery work, while providing many of the same benefits as typical recreation activities, is not typically sought after as a recreational pursuit and therefore should not be categorized as a recreational activity *per se*. Rather, engagement in voluntary hatcheries can be constructed as providing opportunity to achieve a higher good; to give something back to nature and help salmon recover or maintain in the face of environmental (or perhaps political) adversity, perhaps best termed as environmental stewardship.

4.2. Understanding the drivers that keep hatcheries open

Taking these findings into account, it is unlikely that voluntary hatcheries are immediately substitutable solely through other activities such as habitat improvement. In addition to the reasons stated above, preference for hatcheries over other types of conservation activities may be a result of historical path dependencies, political visibility of stocking, or strong social norms by the angler constituency (van Poorten et al., 2011; Riepe et al., 2017). For example, all cases had a long lasting tradition of hatcheries where stocking has been a key management and conservation tool for a long period of time (Berg, 1986; Bottom, 1997; Wolter, 2015), likely transferring hatchery practices into habit. Once this transformation occurs, cessation or substitution of the activity is exceedingly difficult due to loss aversion (Kahneman and Tversky, 1984) in light of the multiple benefits created by hatcheries.

The cultivators in our investigated cases had few, if any, alternative means of pursuing their conservation drive due to substantial legal and economic structural constraints in pursuing habitat work. This is another reason why voluntary hatcheries have become the primary outlet for conservation work by local stakeholders and anglers (Arlinghaus et al., 2015). Anglers "stubborn" allegiance to hatcheries for conservation reflects these constraints, as well as the other benefits they derive from participating in hatchery-based conservation. Importantly, habitat improvement is different from stocking; it demands intensive networking with other social-ecological systems and decision-makers and often suffers from low implementation rates and high costs (Aprahamian et al., 2003; Bilsby et al., 1998). By moving from hatcheries to habitat work, cultivators lose some sovereignty through collaborating with agencies, agricultural sectors, hydropower, water management and other actors. Thus, the transactions costs of habitat management are high, and the way such activities tie into empowerment and abilities of individual anglers to make decisions is substantially different from that of stocking. It is thus unlikely that habitat management activities can easily substitute the benefits derived from voluntary hatcheries from a sociocultural perspective.

Finally, in cases where voluntary hatchery status is under debate, valuation of multiple benefits helps to explain conflict-oriented behavior from both cultivators and managers. From this study, it is clear that the focus on efficacy and cost-effectiveness by some scientists and managers is divergent from the multiple focuses of local cultivators. Thus, groups are valuing and prioritizing the benefits produced by voluntary hatcheries differently. This point is essential as contemporary debates about hatcheries and stocking have focused on efficacy of hatcheries to help conserve wild stocks as compared to economic and opportunity costs, and most scientific discussions relate to the actual contribution (or damage) hatcheries can do to wild salmonid stocks and their environment. This is not the framing local cultivators have about their hatcheries. Consequently, many scientists and managers effectively ignore the many other psychological, social, and conservation benefits produced by voluntary hatcheries which matter to stakeholders.

Assumptions that the drivers for continued local hatchery work on salmon are related primarily to increased opportunities to catch fish are refuted by this study (particularly in the Welsh and Norwegian cases). The same is true for assumptions that the lack of engagement in alternatives to stocking is the result of the inability of cultivators to understand and adapt to new scientific knowledge. Further efforts to manage voluntary hatcheries solely from this framing will likely exacerbate existing conflicts between conservationists, fisheries managers, and local cultivation groups. Moreover, in countries where Atlantic salmon are extinct there is little alternative to engaging in stocking − an activity that must be supplemented by (or perhaps should supplement) large scale habitat restoration. If public managers of rivers and fisheries need or want to restrict or terminate hatchery programs (or hold discussions about such initiatives), our study suggests they must be aware of the multiple meanings cultivators attach to hatcheries and the specific contextual setting in which hatcheries are operated (e.g., extinct wild stocks). Manager and communicators would be well-advised to accept the underlying psychological forces and be cautious in their communications and decision-making if they are to maintain a constructive dialogue.

4.3. Holistic strategies for managing voluntary hatcheries

A key message of this article is the importance of hatcheries to hatchery practitioners, and how they and society gain many important benefits from hatcheries apart from the production of salmon. To that end, management of voluntary hatcheries should be cognizant of and ideally facilitate different types of benefits. While legitimate concerns about hatcheries should not be ignored (Cowx, 1994; Grant et al., 2017; Waples, 1999), managers could shift the focus and purpose of voluntary hatcheries toward a more holistic approach (Lorenzen et al., 2010) by adding non-biological benefits to stocking and hatchery objectives. This shift will require all stakeholders to reach a shared understanding of the goals and objectives underlying hatchery programs, consider trade-offs to achieve multiple outcomes (McShane et al., 2011), and recognize the merits of all stakeholders' arguments and values (Harrison and Loring, 2014; Loring et al., 2014; Redpath et al., 2013). This change in perspective would achieve a broader scope of purpose for hatcheries and avoid alienating stakeholder groups that pursue conservation activities, but who also derive social and psychological benefits from hatchery work.

Until now, cultivators have been incentivized to argue the case in support of hatcheries from a stock-based perspective, engaging in a power dynamic that situates research-based knowledge superior to other knowledge types (Ingram, 2008). However, research on the efficacy of voluntary hatcheries is often insufficient (Cowx et al., 2010), allowing the hatchery debate to continue without sufficient information. Rather than relying upon reactive commentary on top-down proposed policy changes, we recommend a transdisciplinary management approach (Chapin et al., 2010; Cowx et al., 2010; Fujitani et al., 2017) which will achieve four important outcomes: (i) explicit consideration of non-conservation benefits, (ii) jointly-produced knowledge that brings better information into hatchery management and effectively corrects misconceptions held by anglers, cultivators or managers about the achievements of stocking programs (Arlinghaus,

2006; Cowx, 1999); (iii) increase buy-in of non-scientists into research outcomes; (iv) help in conflict resolution.

5. Conclusion

Our study provides new perspectives and information for considering voluntary hatcheries as salmon conservation tools. Voluntary hatcheries provide diverse and bundled psychological, social, and conservation benefits to both cultivators and salmon stocks. These benefits have strong parallels to benefits derived from recreational angling and outdoor recreation, but are likely not replaceable by angling or other already-present recreational activities in these case studies. Decision makers could take advantage of these many benefits by creating better-defined goals and objectives for hatchery and/or stocking projects in harmony and close collaboration with hatchery operators, pursuing joint studies and co-production of knowledge about stocking impacts and outcomes, and better fostering civil engagement toward salmon conservation with anglers and other stakeholders. In this context, managers and policy makers should recognize the many non-conservation benefits that hatcheries provide when implementing outreach and communication strategies to avoid defensive and conflicting situations.

Hatchery groups have the same basic goals of most river and fishery managers – to generate means to help salmon maintain or recover their populations. It will be beneficial to build on this common interest and jointly work toward addressing the overarching reasons for why wild salmon stocks often decline. By contrast, taking an exclusive biological perspective and being overly critical of hatchery efforts promises to create enduring tension with those for whom hatcheries provide the means to generate meaningful civil engagement for salmon conservation. We recommend greater opportunity should be made of cultivator's willingness to participate in a wider set of conservation measures beyond stocking and provide the political and social resources to address the reasons of salmon decline.

Funding

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie project IMPRESS [GA No. 642893]. The first author also received funding from the Oxford Small Travel Grant [2016]. No funding agencies had any role in the study design, execution, or reporting of results.

Conflict of interest

The authors declare that they have no conflicts of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors beyond that which is described in the text. All data collected and used in this study was collected in accordance with the Norwegian Centre for Research Data Authority standard via project #47203.

Contributors

All authors listed have participated substantially in the manuscript's development. Hannah Harrison (HH), Øystein Aas (ØA), and Robert Arlinghaus (RA) designed the study; HH and Sophia Kochalski (SK) collected the data; HH and SK performed the analysis; HH, SK, RA and ØA interpreted the data and wrote and edited the manuscript and its revision. All authors approve the final version.

Acknowledgements

The authors wish to thank all those who graciously gave their participation, knowledge, and time to this study. Thanks also to N.O. Brekke for his translation services, and to NINA staff for their transcription and translation help. Special thanks to the two reviewers and editors of this article who gave helpful critiques and comments to the text.

References

ATLAS.ti, 1999. Scientific Software Development, Berlin.
Amoroso, R.O., Tillotson, M.D., Hilborn, R., 2017. Measuring the net biological impact of fisheries enhancement: pink salmon hatcheries can increase yield, but with apparent costs to wild populations. Can. J. Fish. Aquat. Sci. 74 (8), 1–10.
Aprahamian, M.W., Martin Smith, K., McGinnity, P., McKelvey, S., Taylor, J., 2003. Restocking of salmonids—opportunities and limitations. Fish. Res. 62, 211–227.
Arlinghaus, R., Mehner, T., 2004. A management-orientated comparative analysis of urban and rural anglers living in a metropolis (Berlin, Germany). Environ. Manage. 33, 331–344.
Arlinghaus, R., Tillner, R., Bork, M., 2015. Explaining participation rates in recreational fishing across industrialised countries. Fish. Manag. Ecol. 22, 45–55.
Arlinghaus, R., Lorenzen, K., Johnson, B.M., Cooke, S.J., Cowx, I.G., 2016. Management of freshwater fisheries: addressing habitat, people and fishes. Freshwater Fisheries Ecology. Wiley, Chichester, pp. 557–579.
Arlinghaus, R., Alós, J., Beardmore, B., Daedlow, K., Dorow, M., Fujitani, M., Hühn, D., Haider, W., Hunt, L.M., Johnson, B.M., Johnston, F., Klefoth, T., Matsumura, S., Monk, C., Pagel, T., Post, J.R., Rapp, T., Riepe, C., Ward, H., Wolter, C., 2017. Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems. Rev. Fish. Sci. Aquacult. 25, 1–41.
Arlinghaus, R., 2005. A conceptual framework to identify and understand conflicts in recreational fisheries systems, with implications for sustainable management. Aquat. Resour. Cult. Dev. 1, 145–174.
Arlinghaus, R., 2006. Overcoming human obstacles to conservation of recreational fishery resources, with emphasis on central Europe. Environ. Conserv. 33, 46–59.
Bate, R., 2001. Saving our streams: the role of the anglers' conservation association in protecting English and Welsh rivers. Fordham Environ. Law J. 14, 375–413.
Berg, M., 1986. Det norske laks- og innlandsfiskets historie. Fiskeetaten 1855–1986. History of the Development of Norwegian Salmon- and Inland Fisheries. The Fishery Agency 1855–1986. University Press of Norway, Oslo.
Bilsby, M.A., Cragg-Hine, D., Henry, K., 1998. Cost-benefit analysis: its role in recreational fisheries development and management. In: Hickley, P., Tompkins, H. (Eds.), Recreational Fisheries: Social, Economic and Management Aspects. Fishing News Books, Blackwell Science, Oxford, pp. 279–286.
Blanchet, S., Páez, D.J., Bernatchez, L., Dodson, J.J., 2008. An integrated comparison of captive-bred and wild Atlantic salmon (Salmo salar): implications for supportive breeding programs. Biol. Conserv. 141, 1989–1999.
Bolstad, G.H., Hindar, K., Robertsen, G., Jonsson, B., Sægrov, H., Diserud, O.H., Fiske, P., Jensen, A.J., Urdal, K., Næsje, T.F., Barlaup, B.T., Florø-Larsen, B., Lo, H., Niemelä, E., Karlsson, S., 2017. Gene flow from domesticated escapes alters the life history of wild Atlantic salmon. Nat. Ecol. Evol. 1, 124.
Bottom, D.L., 1997. To till the water—a history of ideas in fisheries conservation. In: Stouder, D.J., Bisson, P.A., Naiman, R.J. (Eds.), Pacific Salmon & Their Ecosystems. Springer, US, pp. 569–597.
Brannon, E.L., Amend, D.F., Cronin, M.A., Lannan, J.E., LaPatra, S., McNeil, W.J., Noble, R.E., Smith, C.E., Talbot, A.J., Wedemeyer, G.A., Westers, H., 2004. The controversy about salmon hatcheries. Fisheries 29, 12–31.
Britton, E., Coulthard, S., 2013. Assessing the social wellbeing of Northern Ireland's fishing society using a three-dimensional approach. Mar. Policy 37, 28–36.
Buoro, M., Olden, J.D., Cucherousset, J., 2016. Global Salmonidae introductions reveal stronger ecological effects of changing intraspecific compared to interspecific diversity. Ecol. Lett. 19, 1363–1371.
Camp, E.V., Larkin, S.L., Ahrens, R.N.M., Lorenzen, K., 2017. Trade-offs between socio-economic and conservation management objectives in stock enhancement of marine recreational fisheries. Fish. Res. Fish. Enhancement 186, 446–459.
Carothers, C., 2010. Tragedy of commodification: displacements in Alutiiq fishing communities in the gulf of Alaska. Mast 9, 95–120.
Chapin III, F.S., Carpenter, S.R., Kofinas, G.P., Folke, C., Abel, N., Clark, W.C., Olsson, P., Smith, D.M.S., Walker, B., Young, O.R., Berkes, F., Biggs, R., Grove, J.M., Naylor, R.L., Pinkerton, E., Steffen, W., Swanson, F.J., 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. Trends Ecol. Evol. 25, 241–249.
Charmaz, K., 2014. Constructing Grounded Theory. SAGE.
Charnley, S., Carothers, C., Satterfield, T., Levine, A., Poe, M.R., Norman, K., Donatuto, J., Breslow, S.J., Mascia, M.B., Levin, P.S., Basurto, X., Hicks, C.C., García-Quijano, C., St. Martin, K., 2017. Evaluating the best available social science for natural resource management decision-making. Environ. Sci. Policy 73, 80–88.
Chilcote, M.W., Goodson, K.W., Falcy, M.R., 2011. Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish. Can. J. Fish. Aquat. Sci. 68, 511–522.
Corbin, J., Strauss, A., 1990. Grounded theory research: procedures, canons and evaluative criteria. Z. Für Soziol. 19, 418–427.
Coulthard, S., Johnson, D., McGregor, J.A., 2011. Poverty, sustainability and human

wellbeing: a social wellbeing approach to the global fisheries crisis. Global Environ. Change 21, 453–463 Special Issue on the Politics and Policy of Carbon Capture and Storage.
Cowx, I.G., Arlinghaus, R., Cooke, S.J., 2010. Harmonizing recreational fisheries and conservation objectives for aquatic biodiversity in inland waters. J. Fish Biol. 76, 2194–2215.
Cowx, I.G., 1994. Stocking strategies. Fish. Manag. Ecol. 1, 15–30.
Cowx, I.G., 1999. An appraisal of stocking strategies in the light of developing country constraints. Fish. Manag. Ecol. 6, 21–34.
Dabrowska, K., Haider, W., Hunt, L., 2014. Examining the impact of fisheries resources and quality on licence sales. J. Outdoor Recreat. Tour. 5, 58–67.
Daedlow, K., Beard, T.D., Arlinghaus, R., 2011. A property rights-based view on management of inland recreational fisheries: contrasting common and public fishing rights regimes in Germany and the United States. American Fisheries Society Symposium 13–38.
Ditton, R.B., 2004. Human dimensions of fisheries. Soc. Nat. Resour. Summ. Knowl. 198–208.
Driver, B.L., Knopf, R.C., 1976. Temporary escape: one product of sport fisheries management. Fisheries (USA) 1, 21–29.
Driver, B.L., 2009. Managing to Optimize the Beneficial Outcomes of Recreation, 1st edition. Venture Publishing, Inc., State College, PA.
Fabinyi, M., Foale, S., Macintyre, M., 2015. Managing inequality or managing stocks? An ethnographic perspective on the governance of small-scale fisheries. Fish Fish. 16, 471–485.
Fedler, A.J., Ditton, R.B., 1994. Understanding angler motivations in fisheries management. Fisheries 19, 6–13.
Fleming, I.A., Petersson, E., 2001. The ability of released, hatchery salmonids to breed and contribute to the natural productivity of wild populations. Nord. J. Freshw. Res. 71–98.
Forseth, T., Barlaup, B.T., Finstad, B., Fiske, P., Gjøsæter, H., Falkegård, M., Hindar, A., Mo, T.A., Rikardsen, A.H., Thorstad, E.B., Vøllestad, L.A., Wennevik, V., 2017. The major threats to Atlantic salmon in Norway. ICES J. Mar. Sci. 74, 1496–1513.
Freudenberg, P., Arlinghaus, R., 2009. Benefits and constraints of outdoor recreation for people with physical disabilities: inferences from recreational fishing. Leis. Sci. 32, 55–71.
Fujitani, M., McFall, A., Randler, C., Arlinghaus, R., 2017. Participatory adaptive management leads to environmental learning outcomes extending beyond the sphere of science. Sci. Adv. 3, e1602516.
Garcia de Leaniz, C., Fleming, I.A., Einum, S., Verspoor, E., Jordan, W.C., Consuegra, S., Aubin-Horth, N., Lajus, D., Letcher, B.H., Youngson, A.F., Webb, J.H., Vøllestad, L.A., Villanueva, B., Ferguson, A., Quinn, T.P., 2007. A critical review of adaptive genetic variation in Atlantic salmon: implications for conservation. Biol. Rev. 82, 173–211.
Glover, K.A., Solberg, M.F., McGinnity, P., Hindar, K., Verspoor, E., Coulson, M.W., Hansen, M.M., Araki, H., Skaala, Ø., Svåsand, T., 2017. Half a century of genetic interaction between farmed and wild Atlantic salmon: status of knowledge and unanswered questions. Fish Fish. 18 (5), 890–927.
Granek, E.F., Madin, E.M.P., Brown, M.A., Figueira, W., Cameron, D.S., Hogan, Z., Kristianson, G., De Villiers, P., Williams, J.E., Post, J., Zahn, S., Arlinghaus, R., 2008. Engaging recreational fishers in management and conservation: global case studies. Conserv. Biol. 22, 1125–1134.
Grant, W.S., Jasper, J., Bekkevold, D., Adkison, M., 2017. Responsible genetic approach to stock restoration, sea ranching and stock enhancement of marine fishes and invertebrates. Rev. Fish Biol. Fish. 27, 615–649.
Haas, G.E., Driver, B.L., Brown, P.J., 1980. A study of ski touring experiences on the White River National Forest. Proc. North Am. Symp. Dispersed Winter Recreat. 25–30.
Harrison, H.L., Loring, P.A., 2014. Larger Than Life: The Emergent Nature of Conflict in Alaska's Upper Cook Inlet Salmon Fisheries 4 SAGE Open 2158244014555112.
Harrison, H.L., 2013. "This Is Who I Am": Perspectives on Economics, Policy, and Personal Identity and Culture of Cook Inlet and Kenai River Salmon Fisheries. University of Alaska Fairbanks, Fairbanks, Alaska.
Hewlett, N.R., Snow, J., Britton, J.R., 2009. The role of management practices in fish kills in recreational lake fisheries in England and Wales. Fish. Manag. Ecol. 16, 248–254.
Holland, S.M., Ditton, R.B., 1992. Fishing trip satisfaction: a typology of anglers. North Am. J. Fish. Manag. 12, 28–33.
Hunt, L.M., 2005. Recreational fishing site choice models: insights and future opportunities. Hum. Dimens. Wildl. 10, 153–172.
Ingram, J., 2008. Agronomist–farmer knowledge encounters: an analysis of knowledge exchange in the context of best management practices in England. Agric. Hum. Values 25, 405–418.
Jonsson, B., Jonsson, N., 2006. Cultured Atlantic salmon in nature: a review of their ecology and interaction with wild fish. ICES J. Mar. Sci. 63, 1162–1181.
Kahneman, D., Tversky, A., 1984. Choices, values and frames. Am. Psychol. 39, 341–350.
Laikre, L., Schwartz, M.K., Waples, R.S., Ryman, N., 2010. Compromising genetic diversity in the wild: unmonitored large-scale release of plants and animals. Trends Ecol. Evol. 25, 520–529.
Lorenzen, K., Leber, K.M., Blankenship, H.L., 2010. Responsible approach to marine stock enhancement: an update. Rev. Fish. Sci. 18, 189–210.
Lorenzen, K., Beveridge, M.C.M., Mangel, M., 2012. Cultured fish: integrative biology and management of domestication and interactions with wild fish. Biol. Rev. 87, 639–660.
Loring, P.A., Harrison, H.L., Gerlach, S.C., 2014. Local perceptions of the sustainability of Alaska's highly contested cook inlet salmon fisheries. Soc. Nat. Resour. 27, 185–199.
Manfredo, M.J., Driver, B.L., Tarrant, M.A., 1996. Measuring leisure motivation: a meta-analysis of the recreation experience preference scales. J. Leis. Res. 28, 188–213.
Manning, R.E., 1999. Studies in Outdoor Recreation: Search and Research for Satisfaction. Oregon State University Press.
Marshall, M.N., 1996. The key informant technique. Fam. Pract. 13, 92–97.
McGregor, J.A., 2008. Well-Being, Poverty and Conflict. (Briefing Paper). ESRC Research Group on Wellbeing in Developing Countries. University of Bath, Bath, UK.
McShane, T.O., Hirsch, P.D., Trung, T.C., Songorwa, A.N., Kinzig, A., Monteferri, B., Mutekanga, D., Thang, H.V., Dammert, J.L., Pulgar-Vidal, M., Welch-Devine, M., Peter Brosius, J., Coppolillo, P., O'Connor, S., 2011. Hard choices: making trade-offs between biodiversity conservation and human well-being. Biol. Conserv. 144, 966–972.
Meffe, G.K., 1992. Techno-arrogance and halfway technologies: salmon hatcheries on the Pacific Coast of North America. Conserv. Biol. 6, 350–354.
Milot, E., Perrier, C., Papillon, L., Dodson, J.J., Bernatchez, L., 2013. Reduced fitness of Atlantic salmon released in the wild after one generation of captive breeding. Evol. Appl. 6, 472–485.
North Atlantic Salmon Conservation Organisation, 2006. NASCO guidelines on the use of stock rebuilding programmes in the context of the precautionary management of salmon stocks. Council Report No. CNL (04) 55.
North Atlantic Salmon Conservation Organisation, 2017. Understanding the risks and benefits of hatchery and stocking activities to wild Atlantic salmon populations. (NASCO Council Document No. CNL (17)61). Report of a Theme-based Special Session of the Council of NASCO. Varberg, Sweden.
Parkkila, K., Arlinghaus, R., Artell, J., Gentner, B., Haider, W., Aas, Ø., Barton, D., Roth, E., Sipponen, M., 2010. Methodologies for Assessing Socio-Economic Benefits of European Inland Recreational Fisheries (Occasional Paper No. 46). EIFAC, FAO, Ankara.
Pretty, P.J., Peacock, J., Hine, R., Sellens, M., South, N., Griffin, M., 2007. Green exercise in the UK countryside: effects on health and psychological well-being, and implications for policy and planning. J. Environ. Plan. Manag. 50, 211–231.
Redpath, S.M., Young, J., Evely, A., Adams, W.M., Sutherland, W.J., Whitehouse, A., Amar, A., Lambert, R.A., Linnell, J.D.C., Watt, A., Gutiérrez, R.J., 2013. Understanding and managing conservation conflicts. Trends Ecol. Evol. 28, 100–109.
Riepe, C., Fujitani, M., Cucherousset, J., Pagel, T., Buoro, M., Santoul, F., Lassus, R., Arlinghaus, R., 2017. What determines the behavioral intention of local-level fisheries managers to alter fish stocking practices in freshwater recreational fisheries of two European countries? Fish. Res. 194, 173–187.
Romakkaniemi, A., 2008. Conservation of Atlantic salmon by supplementary stocking of juvenile fish. Poikasistutukset Atlantin lohen suojelukeinona.
Saltveit, S.J., 2006. The effects of stocking Atlantic salmon, Salmo salar, in a Norwegian regulated river. Fish. Manag. Ecol. 13, 197–205.
Sandström, A., 2010. Institutional and substantial uncertainty—explaining the lack of adaptability in fish stocking policy. Mar. Policy 34, 1357–1365.
Sandström, A., 2011. Navigating a complex policy system—explaining local divergences in Swedish fish stocking policy. Mar. Policy 35, 419–425.
Siemens, M., von Hanfland, S., Braun, M., 2008. Fischbesatz in angelfischereilich genutzten Gewässern. Landesfischereiverband Bayern, München.
Stensland, S., 2010. Fishing rights and supply of salmon angling tourism in Mid-Norway. Scand. J. Hosp. Tour. 10, 207–230.
Stensland, S., 2012. Typology of landowners in Norwegian salmon angling: attitudes towards river owner organisations and management actions. Fish. Manag. Ecol. 19, 273–282.
Swain, D.P., Riddell, B.E., 1990. Variation in agonistic behavior between newly emerged juveniles from hatchery and wild populations of Coho Salmon, Oncorhynchus kisutch. Can. J. Fish. Aquat. Sci. 47, 566–571.
van Poorten, B.T., Arlinghaus, R., Daedlow, K., Haertel-Borer, S.S., 2011. Social-ecological interactions, management panaceas, and the future of wild fish populations. Proc. Natl. Acad. Sci. 108, 12554–12559.
Verspoor, E., 1988. Reduced genetic variability in first-generation hatchery populations of Atlantic Salmon (Salmo salar). Can. J. Fish. Aquat. Sci. 45, 1686–1690.
von Lindern, E., Mosler, H.-J., 2014. Insights into fisheries management practices: using the theory of planned behavior to explain fish stocking among a sample of swiss anglers. PLoS One 9, e115360.
Voyer, M., Barclay, K., McIlgorm, A., Mazur, N., 2017. Using a well-being approach to develop a framework for an integrated socio-economic evaluation of professional fishing. Fish Fish. 18, 1134–1149.
Waples, R.S., 1999. Dispelling some myths about hatcheries. Fisheries 24, 12–21.
Weithmann, S.A., 1999. Socioeconomic benefits of fisheries. Inland Fish. Manag. North Am. 2, 193–213.
Wolter, C., 2015. Historic catches, abundance, and decline of Atlantic salmon Salmo salar in the River Elbe. Aquat. Sci. 77, 367–380.