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The Social, Economic and Cultural values of wild Atlantic salmon

A review of the literature for the period 2009-2019 and an assessment of changes in values

Knut Marius Myrvold
Guy W. Mawle
Oddgeir Andersen
Øystein Aas

Norwegian Institute for Nature Research

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The Salmon of Llyn Llyw carries knights of King Arthur up the Severn Estuary. Illustration from 'The Mabinogion' translated from the Welsh by Lady Charlotte Guest. Bernard Quaritch, London, 1877'.

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CONTACT DETAILS

NINA head office	**NINA Oslo**	**NINA Tromsø**	**NINA Lillehammer**	**NINA Bergen:**
P.O.Box 5685 Torgarden	Gaustadalléen 21	P.O.Box 6606 Langnes	Vormstuguvegen 40	Thormøhlens gate 55
NO-7485 Trondheim	NO-0349 Oslo	NO-9296 Tromsø	NO-2624 Lillehammer	NO-5006 Bergen.
Norway	Norway	Norway	Norway	Norway
P: +47 73 80 14 00	P: +47 73 80 14 00	P: +47 77 75 04 00	P: +47 73 80 14 00	P: +47 73 80 14 00

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Abstract

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Wild Atlantic salmon provide humans with a range of values, benefits and gifts, and several scientific disciplines are needed to provide a sufficiently wide and relevant description of them. A literature review identified 41 studies of the different values of wild Atlantic salmon published between 2009 and 2019, dominated by economic studies. Few studies of the cultural values were identified.

Net and trap fisheries in 2017 were estimated to catch nearly 500 tons, representing approximately 185 000 salmon. At least 5400 people fished for Atlantic salmon with nets and traps mostly in subsistence fisheries valued for their cultural benefits. Few wild Atlantic salmon fisheries are commercial and it is therefore of little relevance to estimate the overall economic value of the catch. Net and trap fishing has fallen from over 5000 licensed units in 2000 to well under 2000 units in 2017. The recorded catch fell by a third from 2007 to 2017 though the estimates are not wholly comparable.

Due to uncertainties in the data, a precise estimate of angling (rod fishing) activity for salmon in 2017 across the North Atlantic is not achievable. Nonetheless, it seems that there were about 300 000 salmon anglers fishing for about 2 000 000 days, to catch about 380 000 salmon in 2017, not including unreported catch. The time series of rod licence sales for some countries indicate general stability in participation from 2007 to 2017, though Norway may have seen decline. Nonetheless, the rod fishery has changed to benefit stock conservation. Though the rate of release by anglers varies greatly between countries, all report a significant increase from 2007 to 2017.

From the national studies, estimates of mean expenditure per angler on salmon angling varied widely from about €100 per day in England and Wales (UK) to over €600 per day in Iceland. It is clear from Canadian and Norwegian studies that there is very wide variation in expenditure per angler and per river, even within one country. Estimates of total expenditures related to angling is likely in the range from m€300 to m€500 in 2017 though this estimate is uncertain. Studies of the cultural values of wild Atlantic salmon show that loss of abundance directly leads to the loss of culture, practices and local knowledge related to salmon. If local knowledge and culture are to survive, they need to be practiced.

A number of case studies confirmed that restoration of wild Atlantic salmon in several rivers, in a range of countries, formerly affected by a range of anthropogenic impacts such as damming, channelization, lethal non-native parasites and pollution, generally were considered beneficial to humans and often providing a significant net economic benefit, across wide groups of the public, also among those not fishing for salmon. In the countries studied, the general public values the status of stocks of wild Atlantic salmon over and above its use for fishing, and those living close by tend to value it more highly.

In the face of continued pressure on salmon and their habitats, an improved reporting of key social and economic monitoring data in NASCO is recommended, to better assess the multiple contributions from wild salmon to people, ultimately also documenting better the potential costs and benefits of restoration and more sustainable management. Key monitoring data are often missing about participation in different fisheries and other non-consumptive uses of salmon, as well as comparable estimates of the total economic value of wild Atlantic salmon.

Knut Marius Myrvold. Norwegian Institute for Nature Research, Vormstuguvegen 40, 2624 Lillehammer, Norway. knut.myrvold@nina.no

Guy W. Mawle, Independent consultant, Aspen House, Tywn-y-sheriff, Usk, NP15 2HT,United Kingdom. guy.mawle@gmail.com

Oddgeir Andersen. Norwegian Institute for Nature Research, Vormstuguvegen 40, 2624 Lillehammer, Norway. oddgeir.andersen@nina.no

Øystein Aas. Norwegian Institute for Nature Research, Vormstuguvegen 40, 2624 Lillehammer, Norway. oystein.aas@nina.no

Sammendrag

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Villaks tilfører samfunnet en rekke verdier og tjenester, og det er viktig å dokumentere denne betydningen ovenfor forvaltning og offentlighet. Formålet med denne rapporten er å dokumentere bredden av verdier slik samfunnet i dag ser dem, samt dokumentere endringer i verdier det siste tiåret. Vi fant 41 fagfellevurderte artikler publisert mellom januar 2009 og mars 2019. Vi fant relativt få studier av den kulturelle betydningen av villaks. De fleste studiene kom fra Norge og Storbritannia. En bibliografi framgår av vedlegg 2 til rapporten. Mye av litteraturen hadde nedgang i bestandsstørrelse eller trussel om bestandsnedgang som bakteppe, noe som er vanlig for økonomisk viktige arter som er i nedgang.

For fiske med fast redskap og garn var den samlede fangsten på nærmere 500 tonn i 2017, noe som tilsvarer 185 000 villaks. Minst 5400 personer fanget villaks med garn eller feller, og det meste av dette fisket skjer som del av en kulturtradisjon som stammer fra husbehovsfiske. I dag er det lite villaks som fanges for kommersielle formål. Vi har derfor ikke beregnet den samlede verdien av fisket med garn eller feller. Antall tillatelser til å fiske med garn eller feller har blitt redusert fra mer enn 5000 i år 2000 til godt under 2000 i år 2017. I 2007 ble det registrert 700 tonn laks fanget i garn eller feller. Tallene for 2017 er ikke direkte sammenlignbare, men antyder en reduksjon på 30% i oppfisket kvantum.

På grunn av usikre data, er et presist estimat på omfanget av stangfisket rundt Nord-Atlanteren ikke mulig å utarbeide. Basert på tallene vi samlet inn, samt anslag for landene som manglet data, anslås det at 300 000 personer fisket rundt 2 000 000 døgn og fanget omtrent 380 000 villaks. For land vi hadde noenlunde sammenlignbare data for fra både 2007 og 2017, har det vært relativt stabil deltagelse i stangfisket, men deltagelsen og antall fiskedager i Norge har trolig gått ned. Fangst av laks gikk ned med 25 000 individer, fra 408 000 i 2007 til 384 000 laks i 2017, tilsvarende en reduksjon på 6%. Selv om andelen fang og slipp fiske varier mye mellom land, rapporterte samtlige land en betydelig økning i andel gjenutsatt fisk i perioden 2007-2017.

Forbruket i de nasjonale studiene varierte fra omtrent €100 per dag i England og Wales til over €600 per dag på Island. Vi finner også stor variasjon i dagsforbruk innenfor samme land, eksempelvis Canada og Norge. Et estimat for samlet forbruk for alt fiske etter laks er derfor beheftet med betydelig usikkerhet men det anslås å ligge i intervallet mellom m€300 og m€500 for 2017. Studier av den kulturelle verdien av villaks viser at tap av biodiversitet fører direkte til tap av kultur, tradisjoner og lokal kunnskap knyttet til villaks. Dersom kunnskapen og kulturen skal overleve, må den brukes.

Case-studier i flere elver og land bekreftet at restaurering av villaksbestander som tidligere var påvirket av menneskelig aktivitet som oppdemming, kanalisering, introduksjon av lakseparasitten *Gyrodactylus salaris* og forurensning er lønnsomt og bidrar til positive økonomiske effekter, også blant dem som ikke fisker villaks. I de land som inngikk i denne studien ser vi at publikum verdsatte villaksen langt over dens verdi for sportsfiske, og verdien økte desto nærmere vassdraget man bodde.

Gitt økt press på villaksen og dens leveområder anbefaler vi NASCO å forbedre systemet for rapportering av sosiale og økonomiske indikatorer, slik at verdiene for samfunnet ved bevaring av villaks tydeliggjøres, men også bedre dokumenterer nytte/kostnadsvurderinger av å restaurere vassdrag og en mer bærekraftig forvaltning av laks. Data som vanligvis mangler er antall fiskere og fiskedøgn fordelt på forskjellige fiskerier, ikke-bruksverdien av villaks og metodisk sammenlignbare estimater av total økonomisk verdi av villaks i de ulike land.

Knut Marius Myrvold. Norsk institutt for naturforskning, Vormstuguvegen 40, 2624 Lillehammer, Norge. knut.myrvold@nina.no

Guy W. Mawle, Independent consultant, Aspen House, Tywn-y-sheriff, Usk, NP15 2HT,United Kingdom. guy.mawle@gmail.com

Oddgeir Andersen. Norsk institutt for naturforskning, Vormstuguvegen 40, 2624 Lillehammer, Norge.oddgeir.andersen@nina.no

Øystein Aas. Norsk institutt for naturforskning, Vormstuguvegen 40, 2624 Lillehammer, Norge.. oystein.aas@nina.no

Content

Foreword

This report is an update of the literature which has been published during the last decade regarding the social, economic and cultural values of Atlantic salmon. The objective is to provide an update of the knowledge about the multiple social, cultural and economic values of wild Atlantic salmon, which aim to support the coming NASCO report about the "State of salmon", which will be an outlet from the international year of the salmon (IYS). IYS is a joint initiative by the North Atlantic Salmon Conservation Organization (NASCO) and the North Pacific Anadromous Fish Commission (NPAFC).

The authors would like to thank the NASCO secretariat, as well as scientists and managers from NASCO member countries for valuable help in providing relevant documents and data needed to complete this work. We would especially mention Martha Robertson (Canada), Michael Millane (Ireland), Dennis Ensing (Northern Ireland, UK), and Jaakko Erkinaro (Finland). We also thank Gudni Gudbergsson of the Marine and Freshwater Research Institute of Iceland (which is currently not a NASCO member, but a key nation for Atlantic salmon) for the provision of detailed data about salmon fisheries in Iceland in recent years.

We also thank Dr Stine Rybråten at NINA for her scholarly assistance with chapter 5.1.3.

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Lillehammer, August, 2019.

Øystein Aas
Project leader

1 Introduction

In 2008, the Socio-Economics Working Group of the North Atlantic Salmon Conservation Organisation (NASCO-WGNAS) collated available social and economic information relating to salmon fisheries across the North Atlantic. The work resulted in the first report (NASCO 2008) that took a comprehensive look at what we now term values of Atlantic salmon. The purpose of the present report is to summarise the published information since then on economic, social and cultural values and benefits of wild Atlantic salmon (*Salmo salar* L.) across the North Atlantic region.

While methods are available to quantify the economic value of fish and fisheries (e.g. for recreational fisheries;(Parkkila et al. 2010), broader and politically-relevant cultural values need full recognition, notably for indigenous peoples, e.g. United Nations (2008) but also for others. This report describes and highlights the variety of values with examples from different jurisdictions. It shows how society's valuation of wild Atlantic salmon can change over time, noting some of the biological, economic, social and political factors that can drive these changes. Gains, losses and other changes are illustrated using case studies drawn from a review of the recent literature. Finally, we provide a bibliography to supplement the previous WGNAS report (NASCO 2008).

1.1 How the wild Atlantic salmon is valuable to people

Defining how wild Atlantic salmon as a species is important to people requires a broad and comprehensive approach to ensure valuation along the same axes with the same units as other organisms. Following trends in valuation of biodiversity and ecosystem services, we draw on framework coined by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The value of some services can be measured in monetary terms, such as provisioning services, while others are difficult to measure due to complex biological functions and processes and lack of market, such as for some social-cultural services (Liu et al. 2019). Of the four categories of ecosystem services defined by the Millennium Ecosystem Assessment (MA, 2005), wild salmon contribute specifically to two categories: provisioning and cultural services. More recently, IPBES "*considers ecosystem services through the lens of Nature's Contributions to People*" (NCP), as outlined in Figure 1.1.

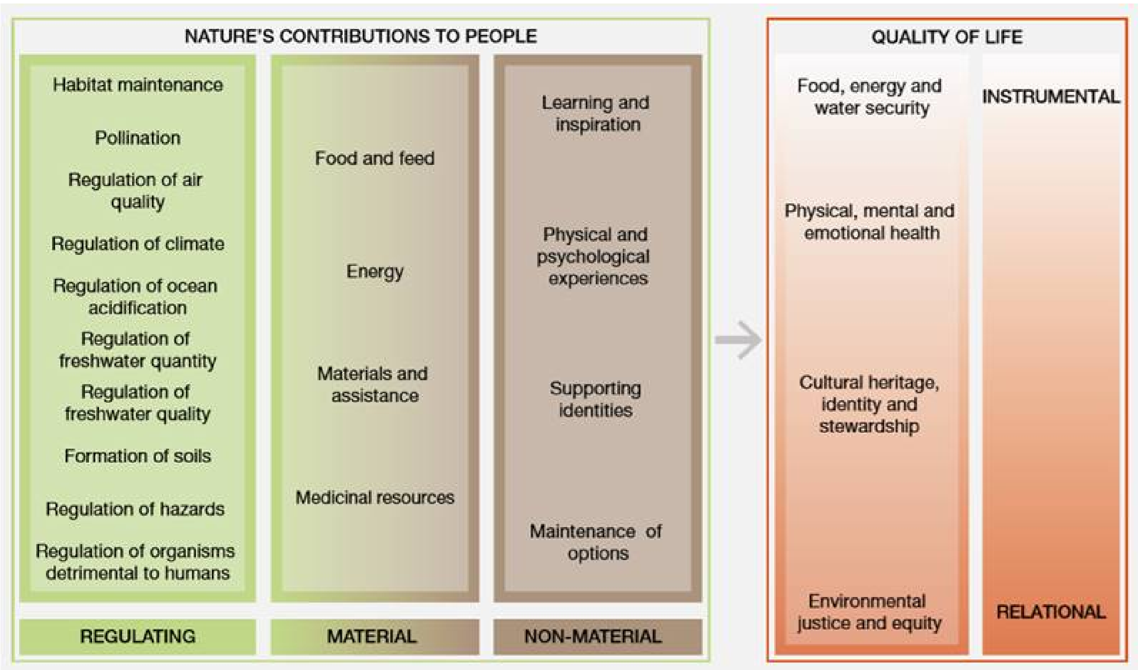

Figure 1.1. Nature's contribution to people and their relation to quality of life in terms of instrumental and relational values. Reproduced from IPBES (2018a).

Cultural ecosystem services are now seen as a mediator of the relationship between people and all forms of NCP (Diaz et al. 2018) and includes "*good quality of life*" in terms of "*human wellbeing*" and "*living in harmony with nature*".

NCP is further divided into 18 categories covering material, non-material and regulating contributions (Figure 1.2). According to this new categorisation, wild salmon contributes to non-material NCP by: 1) learning and inspiration; 2) physical and psychological experiences; 3) supporting identities; and 4) maintenance of options in order to support good quality of life or benefits to future generations. Material NCP are provided by 1) food and feed; 2) materials, companionship and labour; and 3) medical, biochemical and genetic resources. For both material and a non-material services, the wild salmon's contribution to people must be understood in a cultural context (Diaz et al. 2018).

Table 1.1. The 18 reporting categories of nature's contribution to people, grouped into material, non-material and regulating services. Dominating contributions of wild Atlantic salmon in italics. Adapted from Diaz et al. (2018).

	Categories of nature's contribution to people		
	Material	Non-material	Regulating
1.Habitat creation and maintenance			X
2.Polliantion and dispersal of seeds and other propagules			X
3.Regulation of air quality			X
4.Regulation of climate			X
5.Regulation of ocean acidification			X
6.Regulation of freshwater quantity, location of timing			X
7.Regulation of freshwater and coastal water quality			X
8.Formation, protection and decontamination of soils and sediments			X
9.Regulation of hazards and extreme events			X
10.Regulation of detrimental organisms and biological processes			X
11.Energy	X		
12.Food and feed	*X*		
13.Materials, companionship and labour	*X*		
14.Medical, biochemical and genetic resources	*X*		
15.Learning and inspiration		*X*	
16.Physical and psychological experiences		*X*	
17.Supporting identities		*X*	
18.Maintenence of options	*X*	*X*	*X*

Using this framework, we can see that wild Atlantic salmon potentially contribute to the quality of life of many people around the North Atlantic both materially, as food and as an economic driver, and non-materially through the experiences gained from different forms of fishing, but also to people not fishing, through contributions to their identity, learning and inspiration and future options.

Salmon fisheries themselves make both material and non-material contributions. Net and trap fisheries provide high quality food for subsistence in local and indigenous communities and through commercial activity, often commanding high prices (described in case study 1.2 in chapter 5, generating income and employment). Nonetheless, many have a significant non-material side contributing to quality of life. The significance of the latter is specifically recognised in fisheries management in some countries. Examples include the Aboriginal Food, Social and Ceremonial (FSC) fisheries in Eastern Canada and, in England Wales and Norway, fisheries with heritage that use unique local fishing methods (Joks 2016, NASCO 2014) an example is https://vimeo.com/84220974 highlighting the lave net fishing in Wales.

Conversely, rod and line fisheries are primarily recreational, contributing non-materially to the well-being of participants and others. There may also be material benefits for the angler if the catch is retained for food or sale, and more significantly for others through the income and employment generated by anglers' expenditures, in licences, accommodation, fishing gear and food, and so forth (Gardner Pinfold 2011, IFI 2013, Salado & Venkovska 2018).

Other salmon related activities can contribute to people's quality of life such as watching them either directly or indirectly. "Swimming with salmon" is offered as an experience in the Suldalslågen River in Norway (https://www.fjordnorway.com/things-to-do/salmon-safari-river-rafting-salmon-and-trout-fishing-in-suldalslagen-river-p1800073), and they can often be seen leaping at falls or dams (e.g. https://www.visitscotland.com/info/see-do/falls-of-shin-visitor-attraction-p1905721). Furthermore, wild salmon can be watched online on underwater web-cameras (e.g. www.riverwatcherdaily.is/migration#) or in private beats (hs://web.archive.org/web/20161001004133/http://www.suldalslagen.com/public.aspx). As with angling, such activity benefits not only participants but any businesses their expenditure helps support, directly or indirectly.

Even without participation in an activity related to salmon, the species is valued by people for its own sake, including as indicative of good environmental quality (Lawrence & Spurgeon 2007, Riepe et al. 2019). Fishing for them using traditional techniques that are socially and culturally significant is also valued (Simpson & Willis 2003).

Atlantic salmon and salmon angling contribute to heritage, local community, and spirituality and religious experiences. The species appears in folk-tales, such as the Mabinogion (see cover picture) in Wales, and as the 'Salmon of Wisdom' in Ireland. It has provided inspiration for art, including in heraldry, municipality coat of arms and names of places around the North Atlantic (NOU 1999). The non-material cultural services provided by wild salmon include opportunities for learning (Yeomans 2007), other experiences, support place and people's identities and maintenance of options for future generations.

1.2 Defining economic value

Economists use a range of terms to describe and quantify different facets of the services of salmon to society, indicating how benefits are derived, who receives them and in what geographic area, and whether they are gross or net of costs. These are laid out in more detail in Appendix 1, but broadly they can be split into two types, which are fundamentally different and not additive (Lawrence & Spurgeon 2007, Parkkila et al. 2010):

- Economic impact or activity: relating to sales, incomes and employment.
- Total Economic Value (TEV): this includes benefits that may not be realised financially and is net of the costs of production. It aims to quantify in monetary terms the true benefits to society. Key components include economic rent to fishery owners, anglers' consumer surplus, net yield from commercial fisheries, and existence value of salmon and salmon fisheries.

The reason for describing economic value in different ways is to help decision makers understand who would benefit and who would lose from different courses of action or inaction, and by how much.

Economic impact studies estimate jobs and significance to the economy, as Gross Expenditure, Gross Domestic Product (GDP) or Gross Value Added (GVA) and are relatively straightforward, e.g. (Gardner Pinfold 2011, Salado & Venkovska 2018). Gross expenditure, especially at a local level, may be helpful in the absence of GDP or GVA estimates, but it can be misleading. Much depends on where money is spent, whether the goods or services were imported, and to what extent the money spent remains circulating within the economy. Also, the significance may depend on what other options people have for employment. Salmon fisheries are usually in rural communities where other sources of income or employment opportunities may be limited.

Estimating *Total Economic Value* or its components is usually more difficult and mainly relies on estimating people's net willingness-to-pay for some change. In some cases, such as where people would lose some use of the resource, such as a fishery, it may be more appropriate to measure willingness-to-accept in exchange for such a loss.

1.3 The limitations of economic valuation

Economic value is the only technique cohesive enough to provide consistent estimates across multiple users and multiple projects because economic values are always denominated by a unified measure: currency. The concepts of economic value, economic impact, combined with human dimension (HD) techniques are all important elements of a complete policy analysis package. Additionally, HD concepts of value contain significant overlap with economic concepts of value, and, in many cases, HD analysts use the same theory and models as economists to explore their conceptualization of value. However, economic value cannot always in full address fairness, societal well-being, social identity, social capital or distributional concerns. When making policy decisions, the examination of HD concepts of value and economic impacts provides insight in the human context in contrast to the sharpness of the efficiency only criteria found in economic value. Additionally, there may be situations where efficiency or value is not the primary goal of policy makers. Instead, the focus may be on stock conservation, maximizing employment or other rural/community development goals, or securing the future of specific knowledge or practice.

On one hand, economic valuation produces a consistent measure that is comparable across very diverse policy contexts, but on the other hand, it does not incorporate the complete policy impact on society. A combination of methods and metrics may provide a better and more complete picture about the pros and cons of fisheries resource allocations (Parkkila et al. 2010).

1.4 The changing values of salmon

Figure 1.2 illustrates how inland fisheries have followed a generalised life cycle as countries become more developed (Arlinghaus et al. 2002). It seems that this is also true for the Atlantic salmon.

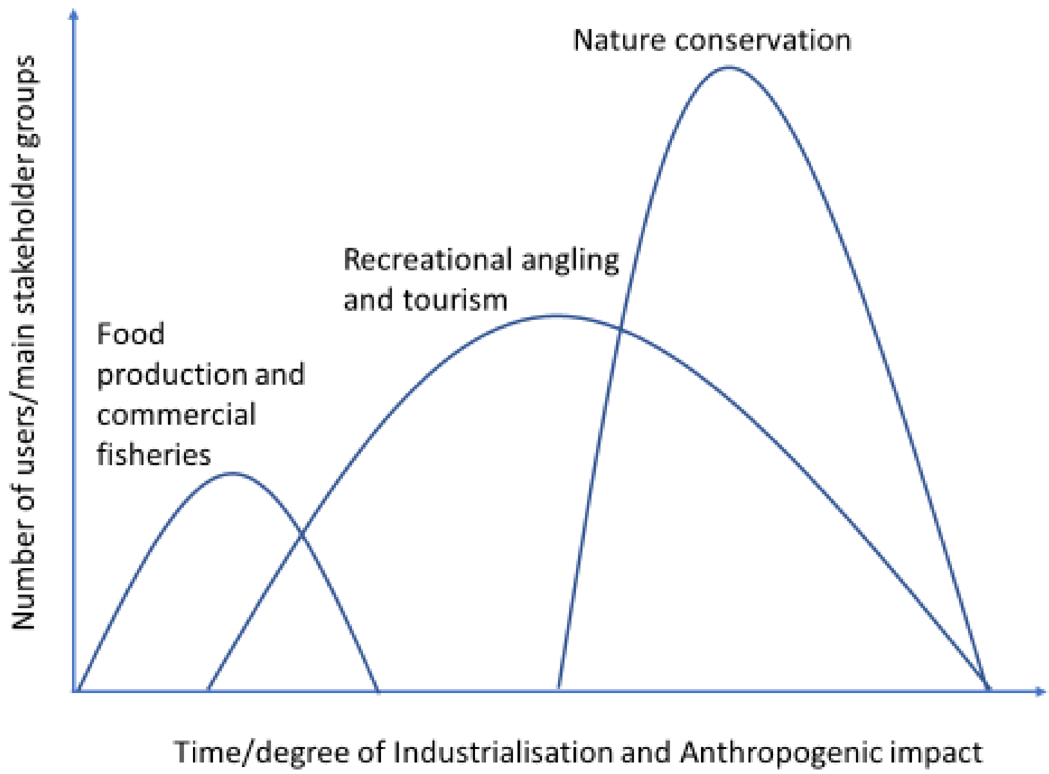

Figure 1.2. Generalized lifecycle of inland fisheries. Evolution takes place along an industrialization gradient where user numbers increases and stakeholder dominance changes (adapted from Arlinghaus et al. (2002).

Different countries around the North Atlantic are in different positions on the horizontal axis. Greenland is perhaps furthest to the left while furthest to the right are the USA, where Atlantic salmon is classified as an endangered species, and parts of Europe, such as Germany where the species had become extinct and many people no longer recognise it as native (Harrison et al. 2018). The ICES Working Group on North Atlantic Salmon in its reports to NASCO has documented the changes (ICES 2018). Commercial fisheries (not for local subsistence or consumption) have closed or been greatly reduced in most countries across the North Atlantic, including the Faroe Islands, Greenland, Canada, Ireland, and the United Kingdom. Recreational fisheries, primarily by angling, now dominate. Even then the food component of angling has been reduced with catch-and-release increasingly practised in all countries (see also Figure 4.4).

There has been an increasing focus on conservation in recent decades, often driven by fisheries interests, leading to the formation of several organisations. In Canada, the Atlantic Salmon Association, predecessor of the Atlantic Salmon Federation, was created in 1948. The Atlantic Salmon Trust was created in the United Kingdom (UK) in 1967. NASCO, an inter-governmental organisation, was created in 1984 to '*to conserve, restore, enhance and rationally manage Atlantic salmon through international co-operation taking account of the best available scientific information*'. The European Union (1992) approved The Habitats Directive to ensure '*the conservation of a wide range of rare, threatened or endemic animal and plant species*', including the Atlantic salmon, across its member states. More recently, the wider conservation movement has increasingly taken an interest in wild Atlantic salmon. The WWF (2001), committed to preserving the world's biological diversity, produced a report on the status of wild Atlantic salmon, though even that focused on the economic activity associated with fishing to demonstrate the value of the species rather than wider economic values.

Public investment, the reduction of some heavily polluting industries, and reduced acidic precipitation, often combined with liming of impacted rivers (Hesthagen et al. 2011, Jøsang 2007, Mant et al. 2013, Navrud 1992), have resulted in major improvements in the (water)quality and accessibility of many rivers in some developed countries. Now, salmon return to rivers from which they had previously been lost or heavily reduced, including in the UK, rivers Clyde and Forth in Scotland and Tyne, Tees, Wear, Trent, Yorkshire Ouse, Mersey, Taff, and Thames in England and Wales (Doughty & Gardiner 2003, Mawle & Milner 2003). Another example is Akerselva, running through Oslo, the capitol of Norway (figure 1.3). Although some now support valuable fisheries, such as the River Tyne in England (UK) or the Skjern River in Denmark (Case studies 3.2 and 3.3 in Chapter 5), attempts to restore a self-sustaining population has often been driven by non-use values, as on the River Thames (Spurgeon et al. 1999) or Akerselva.

Figure 1.3. Salmon angling in Akerselva, in the city centre of Oslo, the capitol of Norway. This river has during the last decade been restored, after suffering from heavily pollution for more than a century. Atlantic salmon are now returning in increasing numbers every year. Photo: Oddgeir Andersen.

The scale of non-use values to the broader population may now be the dominant component of the Total Economic Value of Atlantic salmon in some countries (Riepe et al. 2019). Mawle (2018) noted that across England and Wales (UK), the value of salmon fishing rights was an order of magnitude smaller than the public's willingness to pay to protect salmon stocks from a catastrophic decline, as assessed by (Lawrence & Spurgeon 2007). Much of the public's valuation of salmon stocks may have been linked to its significance as an indicator of good environmental quality.

1.5 What drives changes in value

A key driver for change in the value of salmon is the abundance of the species, which determines what may be taken for sustainable exploitation. Pre-fishery abundance has declined on both sides of the Atlantic Ocean (ICES 2018) since around 1980. While the specific causes are not dealt with here, they generally reflect those identified for the general declines in biodiversity across Western Europe (IPBES 2018a) & North America (IPBES 2018b), including land use, pollution, invasive alien species, impacts from aquaculture, and climate change. Key societal drivers that change how humans value salmon include for instance urbanisation, which affects cultures and practices in how humans relate to nature, increasing interests and social norms towards non-consumptive use, and demographic changes such as an aging population in many countries (Arlinghaus et al. 2002).

Another driver for changes in the value of wild Atlantic salmon, especially its value as food, is the rapid expansion of the salmon farming industry since the 1980s. As shown in Figure 1.4 from ICES (2018), annual production of farmed salmon in the North Atlantic area is now over one and half million tonnes. It has provided an increasingly cheap substitute for wild salmon, though there is still a market for wild salmon. This is illustrated in Case study 1.2 in Chapter 5.

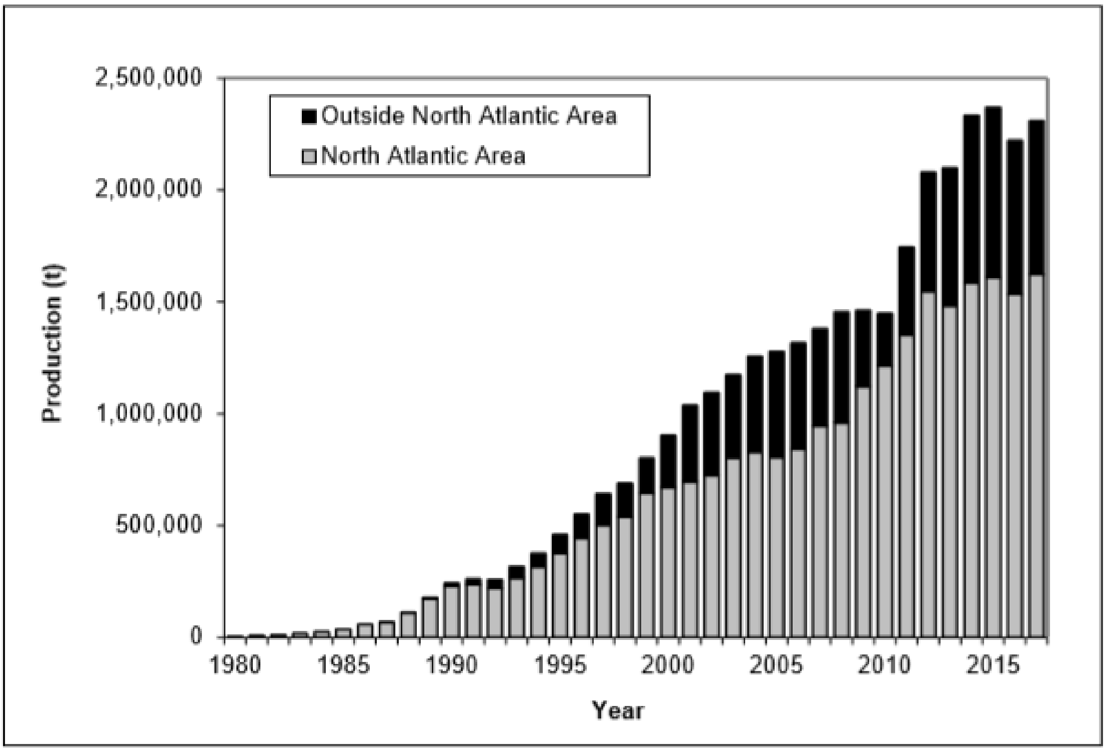

Figure 1.4. Worldwide farmed Atlantic salmon production 1980-2017. Source: ICES 2018.

Social changes will also have contributed to the changing pattern of exploitation from commercial to recreational fisheries. Incomes, especially at the upper end of the income bracket, have increased. Combined with rising populations and improved transport (e.g. cheap air travel) it has expanded opportunities for salmon angling tourism in countries such as Russia, Iceland and

Norway (Stensland 2010, Stensland & Baardsen 2012). The development of the internet has improved the ability to market such opportunities. Improved communication through the internet has also enabled more effective promotion of conservation organisations and education of the wider public about environmental issues, including salmon.

2 Methods

2.1 Literature review

2.1.1 Literature review procedure

There is a large, and rapidly growing body of literature on Atlantic salmon. Due to its commercial value, a large proportion of the articles concern aquaculture and domesticated strains of salmon. For a literature review on the values of wild Atlantic salmon, this poses a major challenge because the relevant papers for our purposes were far outnumbered. We performed a three-tier review process, starting with a narrow search on the Web of Science, then supplementing with a similar search on Google Scholar (as it includes reports and grey literature), and finally we used referrals by experts on the topic (a snowball approach).

We first searched the Web of Science core collection. Searching for "Salmon" or "Atlantic salmon" yielded large numbers of articles: the former search term yielded inflated results due to Pacific salmon (*Oncorhynchus* spp.), whereas the latter search term yielded large numbers of studies on Atlantic salmon farming. Consequently, we limited the query by including more keywords search terms as outlined below:

- Published literature in the period 01.01.2009 – 30.01.2019
- Queried Web of Science in three stages with the following keywords:
- 1st stage:
- Atlantic salmon * economic / cultural / social *values
- Atlantic salmon * economic / cultural / social
- Atlantic salmon * knowledge / traditional knowledge / indigenous
- Atlantic salmon recreation / fisheries / valuation / ecosystem service / social-ecological / angling
- 2nd stage: Salmo salar * the same keywords
- 3rd stage: Salmon * the same keywords

We then searched google scholar with the same keywords. Finally, we used referrals from the project group and partners to obtain articles in the primary literature and reports in the grey literature.

We used a scoring scheme where articles were assigned a score for their value for the review (none, low, moderate, high). For articles that scored moderate or high, we included a classification of their primary value axes (economic, social, and cultural). *Economic values* refer to bioeconomic, cost-benefit and willingness-to-pay analyses, and analyses of the added economic ramifications of wild Atlantic salmon and contributions to local or national economies. *Social values* refer to any measure of social, legal, regulatory or statutory importance of wild Atlantic salmon. Finally, *cultural values* in this analysis refer to any heritage, spiritual, and religious aspects of wild Atlantic salmon to any ethnic or demographic group.

2.1.2 Methodological challenges

Literature reviews and meta-analyses are often challenged by biases in the published literature. Publication bias occurs whenever the research that appears in the published literature is systematically unrepresentative of the population of completed studies. In other words, when the research that is readily available differs in its results from the results of all the research that has been done in an area, readers and reviewers of that research are in danger of drawing the wrong conclusion about what that body of research shows (Rothstein et al. 2005). The causes for this general distortion of information are many. Rothstein et al. (2005) identified a number of causes, including *language bias* (selective inclusion of studies published in English); *availability bias* (selective inclusion of studies that are easily accessible to the researcher); *cost bias* (selective inclusion of studies that are available free or at low cost); *familiarity bias* (selective inclusion of studies only from one's own discipline, and *outcome bias* (selective reporting by the author of a primary study of some outcomes but not others, depending on the direction and statistical significance of the results). (Martin et al. 2012) identified *geographic bias* as another category of bias inherent to observational field studies, a common study method in ecology and natural resources where we typically investigate the relationships between an organism and its environment. Finally, Lee et al. (2012) raised concerns over *biases in peer review*, which could preclude studies from ever being published. All these biases present the same threat to a review's general validity.

We were faced with the same biases when searching for the literature for this report. Atlantic salmon is a widely distributed species, with extant populations in 19 countries and extinct populations in two countries. Most of these countries have distinct languages, cultures, and economic priorities. The biases that relate to geographic representation and language may therefore be particularly important for this literature review. Countries have peer-reviewed journals in their native languages; reports in the grey literature are usually written in the native language; more studies are conducted in countries where salmon play a stronger economic role in society and where more money is allocated to research; and more studies are done in countries with greater spending on basic research and/or stronger environmental regulations.

2.2 Revising the data on direct use values related to fisheries of wild Atlantic salmon

We have updated the tables on catches, estimates of number of fishers and their effort from net and rod fisheries (Tables 4.1 and 4.2) with recent data from NASCO documents and national registers. In addition to potential data found in the general literature review, specific requests were made to the ICES Working Group on North Atlantic Salmon group (WGNAS), and subsequently, specific requests for information were made to country representatives and/or experts. Despite many helpful and rapid responses, there remain substantial gaps as many jurisdictions do not regularly collect socio-economic data.

Due to the lack of detailed socio-economic information in many jurisdictions across the North Atlantic, some basic parameters on participation, relating mainly to 2007, were collated by NASCO for (1) net & trap fisheries; and (2) rod fisheries (NASCO 2010). This split recognises that most net and trap fisheries are commercial, subsistence or cultural fisheries, while rod fisheries are primarily recreational. This report provides equivalent data on catch and participation, where available, a decade later and highlights some changes. It also summarises recent national estimates, where available, of the economic activity supported by the rod fisheries. It would not be appropriate to estimate a commercial value for the overall catch in the net and trap fisheries given that many are for subsistence or cultural purposes.

Much of the information for 2017 comes from NASCO documents, available on the NASCO website (www.nasco.int) and include catch and effort data. However, the data sources have varying degrees of quality and reliability. Unless otherwise specified in the descriptions for individual countries, the data presented in this section are derived from the report of the Working Group on North Atlantic Salmon, WGNAS (ICES 2018). This has been supplemented by personal communications through members of the Group or their contacts. In cases where harvest numbers were unavailable, but the numbers and the proportion of the total rod catch released were available, we calculated the number of salmon taken in the rod fisheries.

While catches of salmon are relatively well documented in most countries, information on participation, i.e. the number of fishers or the amount of fishing activity ("effort") is often imprecise or wholly lacking. Sales of fishing licences, where they exist, provide a useful index of the number of fishers for many countries, such as Norway or Ireland, assuming that there have been no or small changes in the licensing system. Also, the ratio of sales to fishers may not be one to one. Fishing activity is recorded is some countries, such as for net and trap fisheries in Scotland (UK) but again this may not be a direct measure of the number of people involved, which might be important to assess important social values. A few countries have estimates of the number of days fished by anglers. Even then, there may have been changes in the recording systems, as in England and Wales (UK). Where the number of days fished has been estimated by surveys there may be significant and variable sampling error.

Overall, the estimates for 2017 provide an indication of scale but comparisons with those from 2007 should be made with strict caution and an understanding that the data from 2007 and 2017 are not directly comparable.

2.3 Adjusting for inflation

We adjusted economic figures prior to 2015 (such as value estimates) for inflation and converted all local /national currencies to Euros (€). Firstly, when figures were presented in € we present the amount at the time (for example the cost of a project) and the adjusted amount to show the present-day value (February and March 2019). Secondly, when a local currency other than € was used, we present the original figure both in the local currency and € based on the historical exchange rate, and the present-day value adjusted for inflation with today's exchange rate (February and March 2019). We used the default inflation index on http://fxtop.com/en/inflation-calculator.php to calculate present day value adjusted for inflation. We found historical exchange rates on http://fxtop.com/en/currency-converter-past.php . To provide a realistic inflation adjustment we used our discretion when historical values were not clearly dated. For example, if an estimate was done in 2010 but not published until 2012, we used 2010 as the starting point. If it was probably that the valuation was done sometime between 2010 and 2012 we used 1. January 2011 as the starting point. When no date for the valuation was provided, but the year was known, we chose 1. July in the given year as the starting point.

2.4 Selection of case studies

For the case studies reported here we supplemented the core papers from the literature search with any pertinent information on the case. Much information is contained in grey literature such as reports, notes, websites, and legal documents, which rarely show in the initial searches of the primary literature (e.g. on Web of Science or Google Scholar). Here, we used citations in the primary literature as a starting point, used referrals from partners, and conducted searches on the web for further information.

3 Results I: Literature review with an emphasis on the economic, social, and cultural values of salmon

The literature search yielded 41 articles from the primary literature, including indexed reports (Appendix 2). Upon closer review, some articles and reports were deemed less important for the content of this report and were not used in the further analyses. Similarly, many of the reports and articles that we obtained through referrals and when working with the case studies were not encountered in the literature search. As discussed in the methods sections, these shortcomings and biases are inherent to any literature review. We used a scoring scheme where articles were assigned a score for their value for the review (none, low, moderate, high). For articles that scored moderate or high, we included a classification of their primary value axes (economic, social, and cultural). We have summarized the findings by geographic origin (Appendix 3) and types of value (Appendix 4). Based on the literature review we identified some main patterns:

- First, most studies were conducted in Norway (9 out of 41), eight studies did not have a geographic focus, and six studies originated in the United Kingdom. Of the articles that had a geographic focus, four concerned Baltic Sea salmon (which were not a prioritized subject in this report) but nevertheless was included in the literature search. The Baltic Sea studies considered a mixed-stock fishery and were largely conducted in the northern part of the sea where Sweden and Finland are the most involved countries.
- We found relatively few studies on cultural values. This could owe to this subject as a stand-alone topic of investigation is more common in the Pacific states and provinces. It could also be a result of traditional ecological knowledge gradually being more integrated into studies originating in other disciplines. Hence, they may not be treated as frequently as stand-alone publications anymore.
- Studies on willingness-to-pay for non-consumptive use of salmon were largely lacking from this period. Some of these topics might have been included under the umbrella of ecosystem services nowadays, which is becoming an increasingly used catch phrase.
- There were several studies on social aspects of catch-and-release fishing, with Atlantic salmon being the target species.
- There were multiple studies showing the major trends in level of participation, and these went further by grouping participants into “types” of anglers and investigating their motivations, attitudes and personal values related to angling.
- There were no formal studies on social media as an outlet for the social, cultural or economic importance of salmon. This is rather surprising, as social media basically harvests all the information a “typical” survey normally would but at a much grander scale for a fraction of the cost. We expect to see an increase in studies that utilize this source of data in the coming years.
- Finally, several studies investigated conflicts between aquaculture and wild salmon interests.

4 Results II: Participation in salmon fisheries across the North Atlantic and associated values

In this chapter, we present a snapshot of the current scale of socio-economic values of salmon fisheries by 1) nets and traps, mainly for commerce and subsistence purposes; and 2) rod and line, largely conducted for recreation. It is related to a similar snapshot conducted for 2007 (NASCO 2010).

We underline that the two overviews (from 2007 and 2017) are not directly comparable. When collating information from many sources across numerous jurisdictions, the accuracy and precision of the reported values and estimates becomes more prone to methodological insufficiencies and errors. We have chosen to largely present the "raw numbers" in this report to be transparent about the numbers we were able to obtain and to provide as much detail as possible in a single document. Because of the numerous sources of error, we urge the reader to exercise good judgement in the use of the data presented here. It is particularly important to not make direct comparisons between 2007 and 2017 without caution and knowledge of specific jurisdiction or datasets. Differences could be a result of sampling error, coincidences or unreported differences in reporting practices between 2007 and 2017, within and between jurisdictions.

Independent of this, there is merit in using official ICES data of harvest of wild Atlantic salmon as a point of departure. Overall, the total reported (and unreported) nominal catch have declined by approximately 110 tonnes per year since 2000 (Figure 4.1), but the annual reduction was more pronounced from 2000 to 2007. During the last decade the reduction was approximately 50 tonnes per year (2007-2017), and was in 2017 less than half of what was reported in year 2000. Consequently, declines in harvest was more dramatic and uniform from 2000 to 2007 than in the period 2007-2017. The estimated proportions of unreported catches have been reduced, indicating improved reporting systems or changes in how these are estimated.

Overall, this suggests that values directly related to fisheries most likely have reduced significantly, and also that the types of contributions to people that salmon now provide have changed, compared to a couple decades ago.

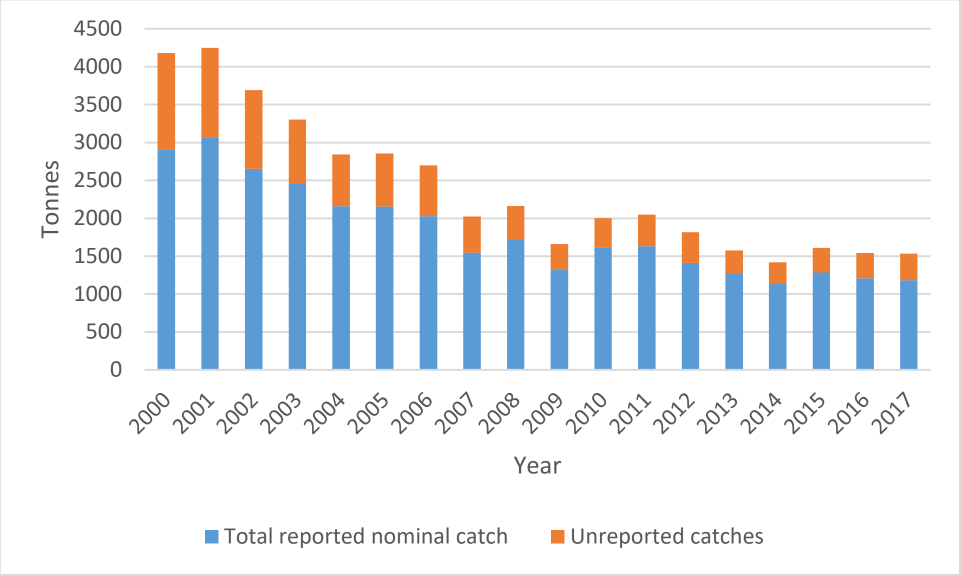

Figure 4.1. Total reported nominal catch and estimated unreported catch of wild Atlantic salmon from 2000-2017. Data from ICES (2018).

4.1 Net and trap fisheries

4.1.1 Overall

For the period 2000-2017, the biggest change happened in 2007, when the Irish drift net fishery was closed. According to ICES, the number of gear units used to harvest salmon with nets and traps have declined by 1/3 from 3275 in 2007 (n=3275) to 2237 in 2017 (n=2237, Figure 4.2). This reflects the closure of many fisheries and increasingly restrictive measures to reduce levels of exploitation in many countries. The number of gear units licensed in Scotland, England & Wales (UK) and Ireland in 2017 were the lowest or amongst the lowest on record. For Northern Ireland (UK), 2017 was the fifth consecutive year that no net fishing activity occurred in coastal Northern Irish waters. In France, the number of nets in estuaries has reduced while the in-river effort has remained relatively stable, with a 10-years average of 45 gear units. In Norway, the country with the by far most remaining net and trap fishery, there was a decrease from around 2500 units in 2000-2002 to around 1200 in 2012, followed by a slight increase.

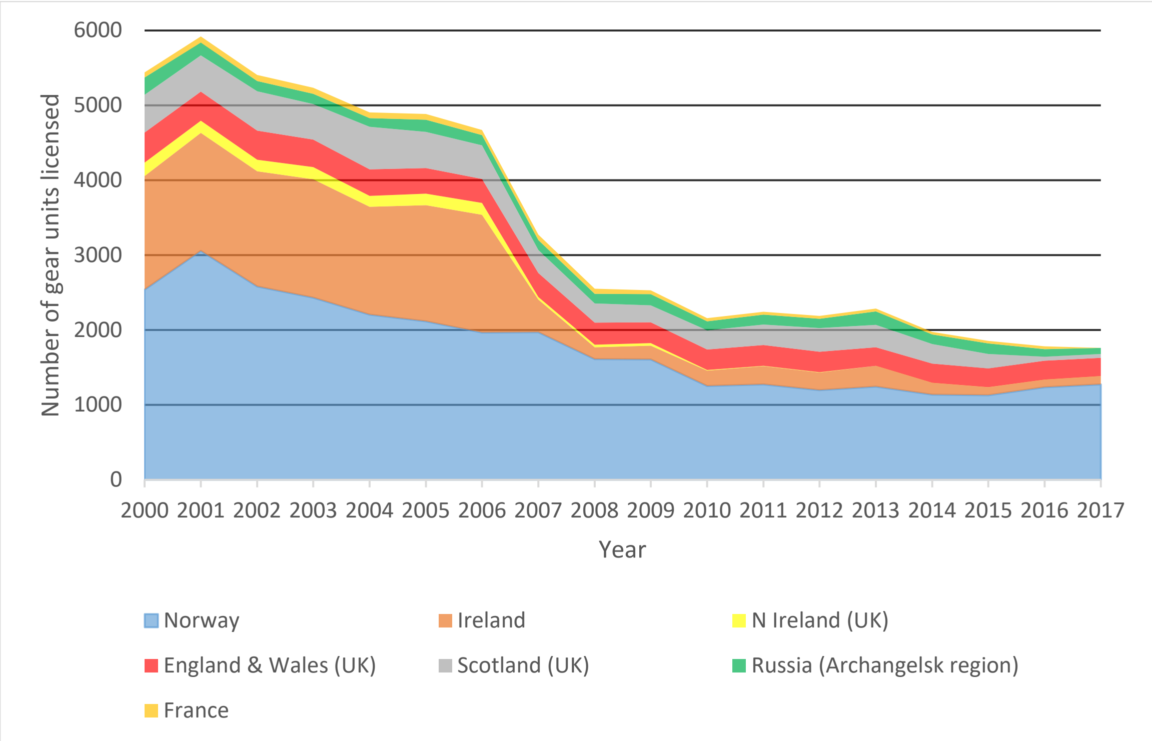

Figure 4.2.Number of gear units licensed or authorised, by country. Data from ICES 2018.

The number of gear units licensed or authorised provides a proxy of effort, but does not take into account restrictions such as reduced seasons or quotas affecting participation. There is no indication from these data of the actual number of licences actively utilized, the number of fishers in total or the time they fished.

The total landed weight recorded in 2017 was 474 tonnes, not including unreported catches (Table 4.1.) Participation data for Canada only represent some, not all provinces with Atlantic salmon. There were still at least 5400 people fishing with nets or traps for Atlantic salmon in 2017. Using the average weight of 3.5 kg for salmon in the nominal catch reported for all North Atlantic fisheries by WGNAS (ICES, 2018), the net and trap fishers caught about 185 000 salmon in 2017.

Table 4.1. The registered/reported weight of salmon caught (in tonnes) and estimates of the number of fishers in using net and trap fisheries in countries across the North Atlantic in 2017, mirrored against figures from 2007 obtained by NASCO. ID = insufficient data.

Country	Weight caught (t) 2017	Number of fishers 2017	Weight caught (t) 2007	Number of fishers 2007
Canada	42	>2329	48	ID
St. Pierre & Miquelon (France)	3	88	3	64
Greenland	28	300	25	105
Iceland	17	52	17	ID
Faroe Islands	0	0	0	0
Russian Federation	13	≥83 licences	35	330 licences
Norway	290	1018 licences	426	1971 licences
Sweden	0	ID	<1	4
Finland	7	460	ID	ID
Denmark	0	0	ID	ID
England & Wales (UK)	40	600	38	971
Scotland (UK)	77	~100	57	503
Ireland	20	400	30	>158
Northern Ireland (UK)	0	0	18	>30
France	6	ID	5	ID
Total	474	>5430	703	>4136

Changes in participation 2007-2017 in the net and trap fisheries are uncertain due to partial or absent data, and to differences in the ways data from 2007 and 2017 were obtained. However, the total recorded catch in net and trap fisheries in 2017 is more than 200 tonnes below the 700 tonnes landed in 2007 (Table 4.1). Official catches in Norway decreased from 426 tonnes to 290 tonnes. Catches plummeted in Scotland (an 88% reduction from 2007-levels) and ended completely in Northern Ireland following changes in regulations (Figure 4.2). Russia reported a decrease from 35 tonnes to 13 tonnes (a 63% decrease) over the same period. Several countries have reduced or stopped commercial fishing, often retaining net and trap fisheries which operate for subsistence or for cultural reasons such as in Canada, Greenland, major parts of Scandinavia and Russia (NASCO, 2014).

4.1.2 Canada

Since 2000, there have been no commercial Atlantic salmon fisheries. The number of fishers is a minimum figure comprising 2058 individual licences for Food, Social and Ceremonial (FSC) fisheries and 271 for resident subsistence net fishers in Newfoundland and Labrador (Martha Robertson, pers. comm.). First nation (indigenous people) access for FSC fisheries is recognised in Canada's Constitutional Act (NASCO 2014). In other provinces, licences are given out to communities rather than individuals, so the number of fishers is unknown.

4.1.3 St. Pierre & Miquelon

This is a coastal net fishery with 8 licences for professional fishermen and 80 for recreational netsmen. Professional fishermen may only sell their catch within the islands.

4.1.4 Greenland

There has been no export fishery since 1998, the catch being used internally with Greenland. Of the 2017 catch, 15.3 tonnes were reported as commercial and 12.7 tonnes for private (subsistence) use. There were 282 licensed fishers of whom 142 reported catches; 50 unlicensed fisheries also reported catches. The total of 300 fishers is a rounded estimate.

4.1.5 Iceland

There are no net and trap fisheries in marine waters in Iceland. Net and trap fisheries operate on some glacial rivers; the number of fishers (n=52) is the same as the number of licences issued; and the gross value of the catch estimated to be 152 000 € (Gudni Gudbergsson, pers. comm.).

4.1.6 Russia

In the Archangelsk region, there were 29 coastal and 54 in-river commercial nets in 2017, compared to 82 and 53 respectively in 2007, indicating a substantial reduction in coastal fishing effort in that region over the decade. A description of the salmon fisheries in the Russian Federation confirms that the effort in the commercial fisheries has been dramatically reduced to conserve stocks and prioritise the recreational fishery (NASCO, 2014). The fishery in the Murmansk and Archangelsk regions is '*viewed as a social measure … a traditional way of fishing by local people from Pomor villages along the White Sea coast*'.

4.1.7 Norway

The reported catch comprised 290 tonnes, reported (ICES 2018). Unreported catch is not included in this figure. A total of 854 bag nets and 419 bend nets (Finnmark only) were licenced in 2017. The total number of licensed instruments was a third lower than in 2007. The number of active salmon fishermen at sea was reduced from 3600 in 1993 to 900 in 2013 (NASCO, 2014). Although some people buy the net-fishing licence, they may not be active. For example, Statistics Norway reported 848 net fishermen in 2017, while the National Salmon Registry (holds information on sale of fishing licences) reported that 1018 people bought a licence for stationary gear (bag net/bend net) in the same year (Figure 4.3.), suggesting that approximately 15 % of those licensed did not fish that year.

There are three rivers in Norway that allow harvest of salmon using nets and traps. In Numedalslågen, the reported in-river catch, caught by nets or traps in 2017 was about 7 tonnes salmon caught by nets or traps in 2017. On the Norwegian side of the Tana, 12.5 tonnes were reported harvested by net or barrier traps in 2017. For the river Neiden, no catch data were available for the traditional and unique Käppälä fishing in 2017, but in 2018 the reported catch from this fishery was 865 kg salmon out of a quota of 1000 kg. Twenty-one partners were in 2018 registered for this Käppälä fishing that occurs for a maximum of 20 days. Many large salmon (>7 kg) are released from the casting net fishing to ensure recruitment in the river.

4.1.8 Finland

The net and trap fisheries are operated by local fishermen, mainly Sami, on the border river Teno and the Näätämöjok is estimated to be 7000 kg (Finnish parts only); an estimated 1000 kg unreported is not included (Jaakko Erkinaro, pers. comm.).

4.1.9 England & Wales (UK)

Most of the catch was taken in a coastal mixed stock fishery which was closed after the 2018 season, along with many smaller salmon net fisheries, for stock conservation. Even where salmon stocks are depleted, some nets have been allowed to continue as sea trout fisheries, releasing salmon; in some cases, local ‘heritage’ value is recognised (NASCO 2014). The number of fishers is estimated as roughly twice the 269 licences issued in 2017, as some instruments require two or more people to operate them. A gross value of 700 000 € is based on a first sale value of the net catch or salmon of 15 £ (16.5 €) /kg (Amec Foster Wheeler 2018).

4.1.10 Scotland (UK)

Marine Scotland (2018) gives fishing effort in 2017 for Scotland as 10 trap months; for net and coble, 40 crew months; and for the Solway Estuary haaf nets used by individuals, 245 net months. Assuming 2 fishers per trap, 4 per net & coble, and one per haaf net; and that all fished a five-month season suggests about 100 fishers in total. Using the same sale value as for England indicates a gross value of the catch in 2017 as €120 000.

4.1.11 Ireland

The major Irish coastal drift net fishery was closed after 2006. Residual fisheries are managed on an annual basis, reflecting stock status, and there has been some further reduction in licences issued for netting since 2007. There are assumed to be four fishers per draft net (Mick Millane, pers.comm.). The gross value of the catch is based on the sale value for England to provide a rough guide.

4.1.12 Northern Ireland (UK)

The net fisheries have been closed since 2007.

4.1.13 France

The latest catch of 6 tons relates to 2016.

4.2 Rod fisheries

4.2.1 Overall

Due to uncertainties in the data, a precise estimate of angling activity for salmon in 2017 across the North Atlantic is not achievable. Nonetheless, it is possible to indicate the scale of activity. The activity in the countries with data presented in table 4.2, sum to 220 000 anglers fishing for just over 1 600 000 days. Taking into account that data of number of angers is missing or only partial for important countries such as Canada, Russia and Scotland, a rounded estimate of number of rod anglers are 300 000. Similarly, number of fishing days are missing or partial for Canada, Ireland, Northern Ireland and as well as for Denmark, Sweden, Germany, France and Spain. In 2007, Ireland, Sweden and France alone reported a total of 320 000 angling days. A rough estimate for number of angling days is therefore 2 000 000. In short, a rough estimate suggests that in 2017, 300 000 anglers fished a total of 2 000 000 days, to catch about 380 000 salmon, not including unreported catch.

*Table 4.2. The reported number of salmon caught, including those released, and reported estimates of the number of fishers (in 1000s) and their effort (days in 1000s) using rod and line to fish for salmon in countries across the North Atlantic in 2017, mirrored against figures obtained by NASCO for 2007. ID = insufficient data. All numbers in thousands. *Missing data from 3 provinces in Canada. ** Data from Russia are minimum figures.*

Country	Caught 2017	Anglers 2017	Fishing days 2017	Caught 2007	Anglers 2007	Fishing days 2007
USA	0	0	0	<1	<1	<1
Canada*	75	>42	>120	80	40	370
Iceland	53	18	42	45	35	180
Russian Federation**	13	ID	>30	51	16	110
Finland	6	3	10	16	9	40
Norway	123	73	730	112	90	900
England and Wales (UK)	14	31	180	20	27	180
Scotland (UK)	49	ID	490	36	ID	470
Ireland	31	18	ID	31	20	200
Northern Ireland (UK)	5	10	ID	10	6	60
Sweden (west coast)	5	ID	ID	4	8	30
Denmark	6	ID	ID	2	ID	ID
Germany	<1	ID	ID	0	0	0
France	2	3	ID	2	2	30
Spain	1	20	ID	ID	ID	ID
Total	384	>218	>1602	410	254	2571

Only where estimates have been made on a similar basis would comparisons between 2007 and 2017 be reasonable. As the basis for many of the 2007 estimates is unclear to the authors of this 2017 compilation, we avoid such general comparisons. However, several countries have time series of licence sales or other measures of angling activity including for Norway, England and Wales (Cefas et al., 2018), as well as Ireland, Finland and France, as recorded by the ICES (2018). On the whole, visual analyses suggest the patterns are quite stable. The slight downward trend in licence sales in Norway may indicate fewer salmon anglers, reflecting dissatisfaction with the quality of fishing (Stensland et al., 2015). Alternative confounding factors are the increase in the age limit for a licence from 16 to 18 years in 2013 and the role of a family licence. Similarly, the increase in sales of licences in England and Wales in 2017 is an artefact of 7000 free Junior licences. The sharp drop in 2017 in the number of anglers fishing the river Teno in Finland is believed to be genuine, reflecting new stricter fishing regulations. Nevertheless, it is likely that the trends are not uniform, and that there have been differential changes in participation across the salmon range.

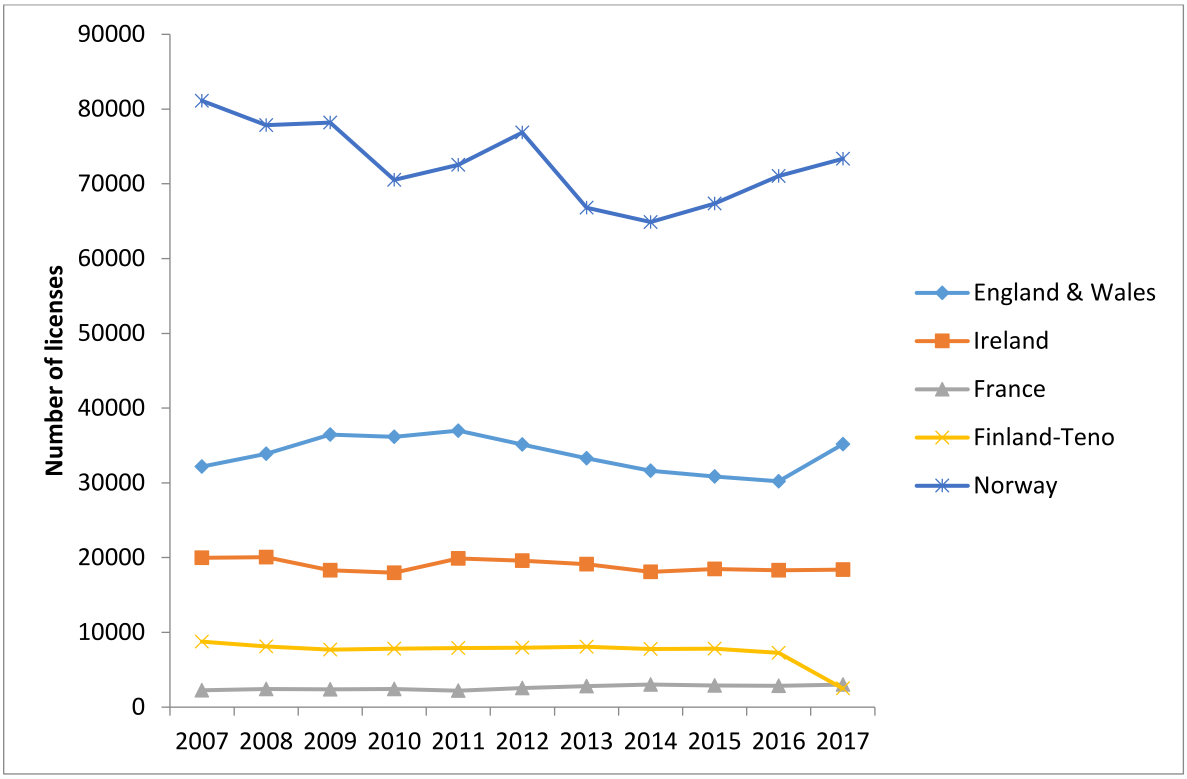

Figure 4.3. Sales of salmon rod licences in some North East Atlantic countries 2007-2017.

Figure 4.4 shows how catch & release rates have increased by time. In 2017, the reported rate of release varied from 15 percent in Sweden, to 90 percent in Scotland (UK). Overall, 179 000 salmon range-wide were reported released in 2017. This represents a significant increase in the number and rate of released salmon since 2007, and illustrates how the utilisation and valuation of salmon, not only management regulations, have changed also in the latest decade. In Scotland for example, the proportion released has increased from 60 to 90 percent, and for Norway from close to zero to more than 20 percent.

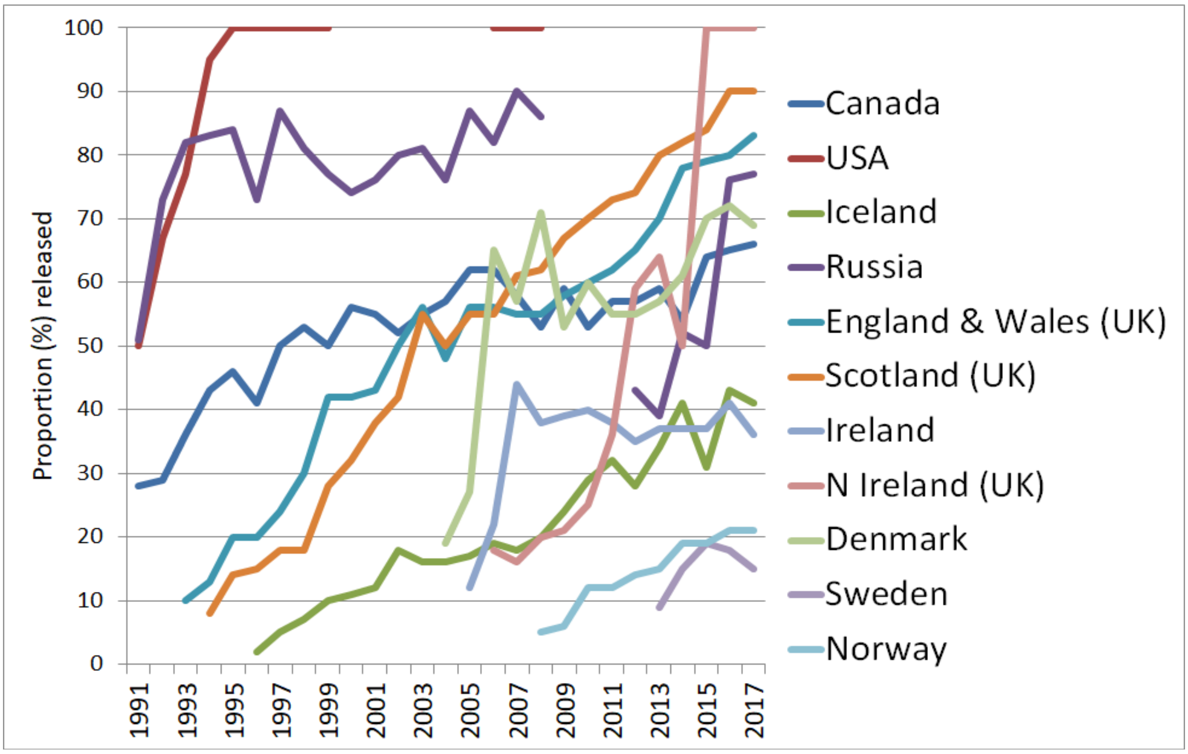

Figure 4.4. Proportions of reported released Atlantic salmon (in % of total river catch, primarily rod fisheries) per year and country 1991-2017.

4.2.2 Canada

There were 39 000 licences issued in 2017 for salmon angling in Newfoundland, Labrador, Quebec and Nova Scotia but equivalent data were not available for other provinces (Martha Robertson, pers. comm.). The most significant omission is New Brunswick, which Gardner Pinfold (2011) estimated was fished by 38 percent of Canadian salmon anglers. Other provinces issue comparatively few licences. Also, there are fewer anglers than licences issued. The number of fishers, 42 000, presented in Table 4.2 is therefore taken from Gardner Pinfold (2011) recognising that, though this may be out of date, it is probably the right order of magnitude.

The number of days fished for 2017 is a minimum comprising 70 000 for Quebec; 8 000 for Nova Scotia; and, down by over 100 000 from 2016 due to stringent management measures, 42 000 for Newfoundland and Labrador (Martha Robertson, pers. comm.). Again, no data were available for New Brunswick and other provinces.

4.2.3 Iceland

Iceland is a popular destination for tourist anglers. About 40 percent of the 42 300 days fished in Iceland in 2017 were made by foreign anglers (Gudni Gudbergsson, pers. comm.). The total number of days fished indicated for 2017 is much lower than the estimate of 175 000 for 2007 but the basis for the latter is unclear. Given that over 90 percent of the available fishing days (47 000) were used in 2017 (Gudni Gudbergsson, pers. comm.), and the catches were similar in the two years, a major drop in fishing activity seems unlikely. The 2017 figure is thus probably more reliable.

4.2.4 Russian Federation

Although data on angler numbers and days fished are limited, Sergey Prusov (pers. comm.) has provided descriptive information. Angling for Atlantic salmon, especially fly fishing, has become very popular. There is a marked difference between salmon angling by foreigners and residents. Angling is only allowed at permitted fishing sites and different sites cater for different markets.

On some rivers like the Ponoi, Kharlovka, and Rynda most anglers were foreigners, though numbers of visiting anglers are now somewhat lower than ten to twenty years ago. For these three rivers, the number of days fished in 2017 was about 3000, so they were thinly spread. Tourist anglers pay high prices for exclusive fishing. For example, the number of anglers (tourists) fishing the lower 100 km stretch of the Ponoi river never exceeded 20 to 24 rods per day. The price for such privileged fishing, catch-and-release only, varied between 5000 and 15000 US dollars (4420-13250 €) per rod per week at one camp. On other rivers such as the Pechenga, Ura, Titovka, Kola, and some White Sea rivers most of the anglers are domestic. A permit for a catch-and-retain fishery on the Kola river was just 5 to 6 US dollars (4-5 €) per six hours for one fish. The Kola River has always been popular with about twenty-five thousand visits per season in recent years.

Figure 4.2. Sportfishing on the Kola river near the Sjongoj village, just south of Murmansk, Russia. Spinning on the near bank and fly fishing on the far bank. Most of the anglers are local from the area. Photo: Øystein Aas

4.2.5 Finland

The number of rod licences issued relates to the two rivers, the Teno and Näätämöjoki. The estimate of the number of days fished, confirmed by Jaakko Erkinaro (pers. comm.), uses data for the Teno with another 20 percent added for the licences issued for the Näätämöjoki. The number of anglers and fishing days dramatically reduced in 2017 following a new fishery agreement between Finland and Norway with the number of fishing days on the River Teno decreasing from 32 000 in 2016 to 10 000 in 2017 (ICES, 2018).

4.2.6 Norway

The later estimate is for 2017 based on the national register for salmon angling (National Salmon Fishing Registry), 73 000 licences were sold in 2017. The number of days fished assumes, based on participation surveys, 10 days fishing per angler per year, recognising that there could be methodological inaccuracies (Anderson & Dervo, 2019). Taking into account minor changes in the licencing system, the rough total number of fishing days in Norway have declined from 900 000 to 730 000 (-170 000 days) since 2007.

4.2.7 England & Wales (UK)

Sales of fishing licences and days fished are provided by (Cefas et al., 2018). The estimate for the number of anglers comprises the number of annual licences issued plus half the number of short-term licences. That assumes each short-term licence holder buys two such licences on average. Although the number of salmon anglers appears to have increased since 2007, this is misleading. In 2017, the total includes 7000 free licences issued to junior anglers most of whom probably only fished for other species, if at all. The number of days fished are for salmon and sea trout and based on catch returns from licence holders applying a correction factor of 1.1 for 2007 and 1.28 for 2017, as used for catches. Although the declared number of days fished for migratory salmonids has roughly halved since 1994, fishing activity in 2017 was similar to that in 2007.

4.2.8 Scotland (UK)

There is no national licensing system in Scotland so the number of anglers who fished there for salmon in 2017 is unknown. Estimates of fishing effort are taken from surveys so they may be less reliable, but an estimate of 490 000 angling days in 2017, is approximately on the same level as in 2007.

4.2.9 Ireland

The estimate of salmon anglers in 2007 and 2017 is based on licence sales though this will be an upper estimate as it includes some short-term licences (Mick Millane, pers. comm.). Sales of salmon licences are far less than the number of salmon anglers estimated by survey in 2012: the number of domestic salmon anglers alone was estimated to be between 69 000 and 91 000 (IFI, 2013). Although anglers are required to submit returns, reports of fishing effort are often missing and unreliable.

4.2.10 Northern Ireland (UK)

No recent data are available for participation in salmon angling. The Loughs Agency issues licences for cross-border areas while the Department of Agriculture, Environment and Rural Affairs (DAERA) issues about 18k ‘game’ angling licences to fish for either salmon or trout. Most of these game anglers will have some interest in salmon fishing (Dennis Ensing, pers. comm.). The estimate of 10 000 is therefore indicative of the order of magnitude only.

4.2.11 France

The number of anglers in Table 4.2 is based on the 3015 licences issued for salmon angling in 2016.

4.2.12 Spain

The rod catch for 2017 is based on the APR reports to NASCO from three regions of Spain, Asturias, Galicia and Navarra (NASCO 2018a, NASCO 2018b, NASCO 2018c). The estimate of 20 000 anglers for the whole of Spain is approximate. Horreo et al. (2011) recorded that 16920 licences were issued in 2008 for five of the most significant salmon rivers in Asturias and Galicia. Although licence sales had been increasing, the catch limit was subsequently reduced so it would be unwise to extrapolate the trend.

4.3 Estimates of angler expenditure and its economic significance

4.3.1 Introduction

The purpose of this subchapter is to illustrate the scale of anglers' expenditure and the economic benefits it can generate in terms of income and employment.

Expenditure associated with salmon is a crude indicator of the contribution of an activity to a local or national economy. For example, a tourist angler might spend €5000 on a fishing trip but that would be little benefit to the area he or she visits if most of the goods and services were bought outside it or imported. To make expenditure more meaningful, account needs to be taken of 1) where the money is spent, 2) how this expenditure ripples through the economy, and 3) where the goods and services purchased come from.

Economic studies therefore focus on expenditure within the area of interest, be it national, regional or local. They also use multipliers to reflect the impact of subsequent expenditure, indirect and induced, generated by the initial expenditure. Gardner Pinfold (2011) provide a helpful description from their study in Canada which is included in Appendix 1.

The metrics generally used to indicate the level of economic activity are Gross Domestic Product (GDP), Gross Value Added (GVA), Incomes, and Full-Time Equivalents (FTEs) of employment. GDP and GVA take account of the import content of goods and services purchased. GDP takes account of taxes and subsidies (Brereton 2006). GVA may be considered a proxy for household income (Radford et al. 2007).

Knowing the level of economic activity associated with expenditure indicates the general relevance to incomes and employment of salmon related activities. Nonetheless, it is more useful for decision makers to know the economic impact of a change in the level of fishing activity, up or down (Parkkila et al. 2010). A small current level of economic activity does not mean it could not be substantially increased if stocks were boosted. Alternatively, if salmon angling were to cease, not all associated expenditure would be lost. Although tourist anglers might spend their money elsewhere, domestic anglers might divert theirs to other types of local fishing, such as trout fishing, and even if they go salmon fishing elsewhere, they might still spend money locally in preparation. It may be helpful to consider the economic impact of marginal changes in fishing activity, such as the change in GVA and FTEs per thousand days fishing (Mawle & Peirson 2009).

Since the studies used in this report were carried out over a decade, we have adjusted economic numbers for inflation, as described in chapter 2.3. In cases where economic values are reported in other currencies (USD, CAD or £), we have converted economic values into €.

4.3.2 National studies

Countries: Canada, Norway, England (UK), Wales (UK), Scotland (UK), Iceland.

Canada Key reference: Gardner Pinfold (2011)

What was measured?

The work was part of a wider study, including of other salmon-related expenditure and its economic significance, including aboriginal food fisheries, academic research, and by government and non-governmental organisations. Expenditure in Canada by anglers fishing for Atlantic salmon in five eastern provinces was estimated from a survey of members of the Atlantic Salmon

Federation extrapolated to the numbers of licensed salmon anglers. This was supplemented by surveys of anglers at high economic impact angling camps.

The Statistics Canada input-output model was used to estimate GDP, employment and income supported by anglers' expenditure, in individual provinces and nationally, and multipliers used to account for indirect and induced effects.

Results

- Average annual spending was highest for visitors from other parts of Canada, followed by visitors to Canada, with least spent by provincial residents. Nonetheless, most (70 percent) of the expenditure was made by residents; 17 percent by other Canadians; and 13 percent by visitors to Canada.
- On average, excluding the 'high spenders', the annual expenditure per individual was CAD 2400 (2788 CAD /€ 2162 in 2019). Average annual expenditure at 'high economic impact' camps was CAD 7800 (9061 CAD / €5935 in 2019).
- Overall, angler expenditure was estimated to be 128 M CAD (m€99.3), three-quarters of all salmon-related expenditure of 166 mCAD (m€129). Adjusted for inflation, these figures were m€98.9 and m€128 in 2019, respectively CAD 166 million.
- Expenditure by salmon anglers created 115 mCAD in GDP; 3,300 FTEs in employment; and 100 M CAD in income. This equals m€87.5 and m€76 in 2019, respectively.
- Of the CAD GDP, 49 percent was due to direct spending; 30 percent to indirect spending; and 21 percent to induced economic activity.

Norway Key reference: Andersen and Dervo (2019)

What was measured?

During the last decade, there have been two estimates of the total, direct use values (DUV) from salmon angling in Norway (Norwegian Forest Owner's Federation 2010 and Andersen & Dervo 2019). Direct use values include expenditures for fishing permit (and the national licence), accommodation and other expenses (food, travel costs etc.). The value of the weight of the catch was not included in the estimates from 2018. The estimates were based on data from the Norwegian salmon angling fee registry (number of licenses), in addition to former national surveys of hunting and angling participation, describing their effort and leisure activity. Data on expenditures was retrieved by a specific survey among salmon anglers in 2018.

Results

- In 2010, the estimated DUV was m€141.4, with a predicted potential to reach m€244.2 in year 2020. However, the 2020 prediction seems quite optimistic, given the fact that number of salmon anglers have decreased (for details, see Figure 4.3.).
- The most recent estimate was conducted by Andersen and Dervo (2019), who estimated anglers' daily expenses and related to salmon angling in Norway 2018. The average daily expenses for salmon angling was estimated to €187.6 per angler. The total consumption related to salmon angling in Norway was m€129.
- In 2018, 73 000 anglers accounted for 730 000 angling days, which equals 46% of the total reported effort in 2017 (Table 3.2).

England (UK) Key reference: Salado and Venkovska (2018)

What was measured?

The study was an evaluation of all type of angling on inland fisheries in England by English residents who held a state rod licence in 2015. It excluded expenditure by anglers from elsewhere. It also excludes the 21 m £ (m€29.6) or so expenditure by anglers from everywhere on state rod licences, of which about 1 m £ (m€1.41) was for licences that included salmon. The database of rod licence holders resident in England was used as a sampling base for an online survey, with a smaller telephone survey to check for bias. Anglers' expenditure was divided into trip-based and non-trip related items. Only trip-based expenditure was specifically allocated to different fish species. National input-output tables were used with regional multipliers. The multipliers used did not include induced effects. Gross Value Added (GVA) and employment (FTEs) were used to indicate the economic activity supported.

Results

- Salmon and sea trout angling accounted for an estimated 133,000 days fished, less than one percent of the total of 22.3 million days fished for all species on inland fisheries.
- Trip-related expenditure on salmon and sea trout angling was 7.3 m £ (m€10.3), 0.7 percent of the 1.06 billion £ (€1.5 billion) spent on angling trips to all inland fisheries in England.
- The total trip and non-trip related expenditure was 1.7 billion £ (€2.4 billion) supporting 1.46 billion £ (€2.06 billion) in GVA and 27,000 FTE jobs.
- If the contribution of salmon and sea trout angling were similar to that on trip-based expenditure, 0.7 percent, salmon and sea trout angling in England by resident anglers would have supported about 10 m £ (m€14.1) in GVA and about 200 FTE jobs in the country.
- As there were about 22,000 salmon licence holders resident in England in 2015 (Environment Agency 2017) annual expenditure per licence holder on salmon and sea trout fishing in England would have averaged about £540.
- The average expenditure per day fished for salmon and sea trout would have been about 90 £ (€127).

Wales (UK) Key reference: Mawle (2018)

What was measured?

This review considered several facets of the economic value of angling on rivers in Wales. An estimate of the economic activity, as GVA and employment (FTEs), supported by salmon and sea trout angling was based on an earlier study by Radford et al. (2007) adjusted by reported reductions in angling activity from 2005 to 2016. The earlier study used surveys of rod licence holders to estimate cross-regional activity and expenditure. All UK anglers were included, not just Welsh residents. Radford et al (2007) used a regional input-output model and multipliers that included both indirect and induced effects. Given uncertainties over precision, estimates were given to one significant figure with adjustment to 2017 prices.

Results

- An estimated 130, 000 days fished for salmon and seatrout in Wales in 2016 was used, recognising that this was double an alternative estimate of 61,000 days based on licence holders' adjusted returns.
- Anglers spent an estimated 10 m £ (m€14.1) fishing for salmon and sea trout in Wales in 2016, supporting 5 m £ (m€7) of GVA and about 200 FTEs in employment.
- No estimates of expenditure per angler or the number of anglers were presented but the average expenditure is about 80 £ / €113 per day fished for salmon and sea trout, similar to the English study.

Scotland (UK) Key reference: PACEC (2017)

What was measured?

This comprehensive evaluation of wild fisheries for salmon and sea trout and other inland fisheries in Scotland included some net fisheries but was dominated by angling. It was based on surveys of both fisheries and anglers in 2014, mainly online. It drew comparisons with a similar study a decade earlier. As well as using input-output tables for Scotland, multipliers were applied to account for indirect and induced effects. Consideration was given to the proportion of economic benefits that would be lost to Scotland if fishing ceased.

Results

- Salmon anglers spent, on average, 4700 £ (€6630) a year on fishing though some of that would have been attributable to fishing for other species.
- Half a million (40%) of the 1.25 million days fished in 2014 were for salmon and sea trout. This equals 30 % of the total effort reported in Table 3.2. Though a greater proportion of anglers' expenditure would have been directed at these species. The 2004 study had estimated that 65 percent of all anglers' expenditure was on salmon and sea trout angling when this type of angling also accounted for 40 percent of fishing effort.
- Expenditure on angling for all species amounted to 135 m£ (m€190) annually, supporting 80 m £ (m€113) as GVA in Scotland and employment of 4,300 FTEs, many as seasonal jobs, both at fisheries and off-site. If 65 percent of this were attributable to salmon and sea trout angling as in 2004, 88 M £ (m€124) would have been spent equating to about 180 £ (€254) per day and supporting annually about 50 m£ (m€70.5) as GVA and 2,800 FTEs in employment.
- It was recognised that, were angling for salmon and sea trout to cease for any reason, some expenditure on angling would be diverted elsewhere within Scotland. Nonetheless about 60 percent would be lost to the economy, i.e. a loss of about 30 m £ (m€42) as GVA and 1800 FTEs.
- Angling activity for salmon and sea trout was similar to that in 2004 but future reductions were expected due to declining stocks.

Iceland

Key reference: Ottesen (2018) and Gudni Gudbergsson (pers. comm.).

What was measured?

This study included an estimation of the economic activity associated with salmon and trout angling in Iceland, mostly attributable to salmon. It was expressed as Gross Domestic Product (GDP) to account for the imported share of goods in anglers' expenditure. Revenues from angling were compared with those recorded in 2004 by the Institute of Economic Studies to identify how they had changed. In addition, we used information from Gudni Gudbergsson, (pers. comm.) about number of angling days and average daily expenditure.

Results

- Total expenditure related to salmon and trout angling was m€80, of which 45 percent was spent on angling permits.
- Foreign anglers accounted a large proportion of this expenditure.
- The average, daily expenditure was €628/day
- The contribution of salmon and trout angling to the Icelandic economy, as GDP, was m€ 65.
- After accounting for inflation, real revenues from the sale of angling permits had, since 2004, increased at 5.8 percent per year, on average.
- The estimated number of rod days was 42 300, which gives an estimate of total expenditure (42 300 days × €628) of m€27.

Summary of daily national mean expenditure on salmon angling

From the national studies, summarised in Table 4.3, estimates of mean expenditure per angler on salmon angling varied widely from about €100 per day in England and Wales (UK) to over €600 per day in Iceland. It is clear from the Canadian study (Gardner Pinfold 2011) that there is very wide variation in expenditure per angler, even within one country. We also provide some examples of the variation within a country (Norway) in chapter 4.3.3. Based on data on average expenditure per day in the studies reported in Table 4.3 and the local studies reported in Table 4.4, the average daily expenditure per angler is probably within the range of €150-250 €/day.

Table 4.3. Summary table of expenditures reported in the national studies. Estimates for daily expenditure are rounded to the nearest €10. Figures are adjusted for inflation to 2019 prices.

Country (year of study)	Salmon angler expenditure (annually)	Average expenditure per person/day
Canada (2011)	m€99	
Iceland (2018)	m€80	€630
Norway (2018)	m€129	€190
UK-England (2015)	m€8	€100
UK-Wales (2016)	m€9	€90
UK-Scotland (2014)	m€76	€210
All	Total: m€402	

4.3.3 Local economic impacts

Here we report estimates of economic impact from salmon angling on a catchment level from some of the most popular salmon rivers in Norway and Canada. In Norway, the salmon season, with some exceptions, runs from 1 June to 31 August (≈90 days). Only a few river management boards have employed persons in a full-time position (e.g. River Alta, Orkla, Gaula or other large landowners/estates like the Finnmark Estate) related to salmon angling. One example of typical part-time employment related to salmon angling/rivers are private or public land managers, who also are responsible for the daily management of the public land area including small- and big game hunting and inland fishery. The most typical seasonal jobs relates to guides and employees at lodges, hostels and restaurants with salmon anglers as a major clientele during summer.

The anglers' consumption is divided into fishing permit (in the particular river) and other expenses (food, accommodation, transport etc.). The larger Norwegian rivers, such as Gaula and Orkla have normally a mix of sections with public access and exclusive sections with limited numbers of permits, often sold in packages with lodging and guide services. On the other hand, Lærdal has primarily exclusive fishing with fewer anglers and angling days, commanding high prices for the exclusive permits needed.

The estimates of direct income from fishing fees equals approximately 30-33% (1/3) of the total expenditure from anglers in these Norwegian rivers. Hence, 2/3 of the salmon anglers' total expenditures relates to other services (food, accommodation etc.) from businesses in the catchment area and can be of high importance. One exception is the high-priced Lærdal river, where only 32% of the total expenditure relates to other expenses (Table 4.4.).

When transforming the estimated total expenditure and angling days per river into average daily expenditure per angler, Stjørdalselva had a daily expenditure of €122 per angling day, Gaula had €138 per angling day, while Beiarn, Namsen and Orkla had respectively €148, €152 and €155 per angling day. The Lærdal river had an average daily expenditure of €267 per angling day.

Gardner Pinfold (2011) present in the four Canadian case studies only the total expenditure per river, but not the number of anglers or fishing days. Hence, we are not able to estimate daily expenditure in these rivers (Table 4.4). Nevertheless, it can be observed that the expenditure on the river level is relatively similar in these Norwegian and Canadian rivers, ranging between 2 and m€8/year, with the large Miramichi system as an outlier.

Table 4.4. Estimates of annual local economic expenditures in Norwegian and Canadian rivers, based on number of anglers, estimated number of angling days, and daily expenditure divided into fishing permits and other expenses.

River	Number of anglers	Angling days	Fishing permits (m€)	Other expenses (m€)	Total expenditure m€
NORWAY					
Gaula	5400	54 900	2.32	5.24	7.56
Orkla	4500	44 400	2.12	4.78	6.90
Namsen	3750	31 700	1.48	3.34	4.83
Stjørdalselva	1900	19 400	0.72	1.63	2.36
Beiarn	1500	14 700	0.67	1.50	2.17
Lærdal	1250	6300	1.15	0.53	1.68
CANADA					
Exploits	-	-	-	-	2.65
Margaree	-	-	-	-	2.19
Miramichi	-	-	-	-	>14.7
Grand Cascapedia	-	-	-	-	4.68

Conclusion
Total expenditures of rod fisheries in the countries which have such estimates, sums up to approximately m€400/year. They make up a large share (between 80 and 90 %) of overall angling effort for Atlantic salmon in the North Atlantic (Table 4.3.). If we extrapolate these numbers, we get a rough estimate - based on national studies - of total angling expenditures related to wild Atlantic salmon around the North Atlantic of nearly m€ 500.

Calculating from number of angling days, given 1 600 000 reported angling days (Table 4.2) and lack of data from countries that in 2007 reported 320 000 angling days, there are reason to believe that the total effort is in the range of 2 000 000 angling days. Further, based on the figures in table 4.3 that average daily expenditures are in the range from €150 to €250, this multiplies to an interval from m€300 to m€500 in 2017.

Given these simple and uncertain calculations, this indicates that salmon anglers' total expenditures across the North Atlantic in 2017 are within the range of m€300-500.

5 Results II - Case studies

To highlight the diverse aspects of the linkages between Atlantic salmon values, conservation and management we present 8 case studies, listed in Table 5.1 below. The case studies cover the three main approaches to "values" but differ with regards to jurisdiction, context, and why understanding values is interesting from social, managerial and conservation perspectives. We present them in 3 main sections: 1) Aspects of value of Atlantic salmon, 2) Changes in values and 3) Rivers reborn, which somewhat more specifically than 2) describes outcomes of restoration efforts. The goal is to show the wide-ranging importance of wild salmon to society, and how it has changed. We include a reference list at the end of each case study and urge the interested reader to visit these resources for further information on each case.

Table 5.1. List of case studies presented in this report, including its geographic location and the type of values considered (economic, cultural, or economic).

Section	Case	Country	Type of «value»
1	**Aspects of value of Atlantic salmon**		
	1.1 Total economic value of salmon in Canada and the United States	Canada, England & Wales (UK), and Ireland	Economic
	1.2 Changing value of commercially caught salmon in Scotland	Scotland (UK)	Economic impacts
	1.3 Maintaining cultural connections with salmon in modern management	Norway and Canada	Cultural
2	**Changes in use and/or values**		
	2.1 Response by anglers to shifting management regimes	Canada and Norway	Social
3	**Rivers, reborn**		
	3.1 Dam removal as a strategy for salmon recovery	France and the United States	Economic and social
	3.2 Habitat restoration in the Skjern River	Denmark	Economic and social
	3.3 Economic activity associated with restored salmon stock in the River Tyne	England (UK)	Economic
	3.4 *Gyrodactylus salaris* in Norwegian rivers	Norway	Economic impacts

5.1 Examples of the multiple values of Atlantic salmon

Countries: Canada, England, Scotland & Wales (UK), Ireland, Norway

Purpose: Describe different aspects of the value of Atlantic salmon

5.1.1 Total Economic Value (TEV) of salmon

Countries: Canada, England & Wales (UK), and Ireland

Purpose: To illustrate the potential scale of the Total Economic Value (TEV) of salmon stocks and factors that can affect it.

Introduction

Parkkila et al. (2010) distinguish between two types of benefit from fisheries, economic value and economic impact: "*Economic value refers to the net benefits received by society, while economic impacts trace the flow of economic activity through a local economy… the concepts of value and impact refer to fundamentally different economic frameworks".* They describe the concept of Total Economic Value (TEV) as: "*A central concept of environmental and welfare economics … It is measured by the preferences of individuals (recreational anglers, fishery owners, commercial fishermen and the public) … and reflects the benefits humans gain from the direct or indirect use and non-use of the natural environment".* Basic components of Total Economic Value are shown in Figure 5.1.

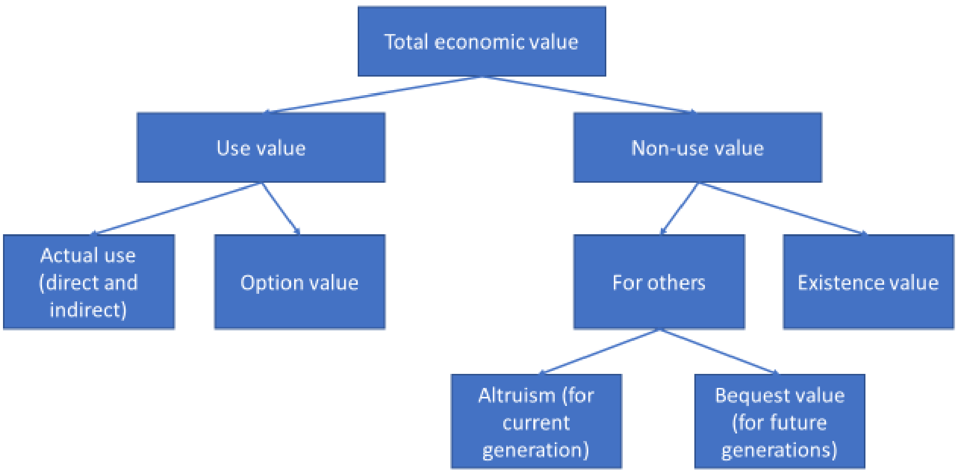

Figure 5.1. The basic components of Total economic values (TEV). Redrawn from Parkkila et al. 2010.

In their study of value of salmon in Canada, Pinfold (2011) recognise most of the same components as Parkkila et al. (2010), and summarise them as follows:

- Direct Use Values (e.g. fishing, wildlife viewing)
- Indirect Use Values (e.g. fishing for a species that depends on salmon for food)
- Option Values (i.e. the value of deferring use of a resource until later)
- Quasi-Option Values (i.e. the value of information in the future)
- Non-use Values:
  - Existence Values (e.g. the value individuals derive from knowing salmon exist…)
  - Bequest Values (e.g. the value individuals derive from knowing that salmon will not be extinct and remain available for future generations).

Total Economic Value in Canada
Key reference: Gardner Pinfold (2011)

What was measured?

Gardner Pinfold (2011) state that "*The total estimated value of salmon related activities in eastern Canada is 255 million CAD".* Assuming an average exchange rate of 1 CAD = €0.70 from 2009 to 2012, this amounted to m€179 in 2011, or m€192 in 2019. To produce this, the authors combined:

(1) the economic impact of current spending, 150 mCAD / m€105 as Gross Domestic Product (GDP), on salmon related activities; and
(2) the general public's willingness-to-pay of 105 mCAD /m€79 annually for a potential future programme to restore salmon stocks.

Although Gardner Pinfold use a standard definition of the components of TEV, shown in Box 1, combining these two facets of economic value is confusing. The two different concepts, i.e. economic impact and net economic value, are considered by others (e.g. Lawrence & Spurgeon, 2007; Parkkila et al., 2010) to be non-additive. As such, it is not clear what the combination represents.

However, the estimate of the public's willingness-to-pay for a programme to restore salmon stocks does indicate part of the Total Economic Value of restored salmon stocks, i.e. the additional benefits that would be associated with better stocks than in 2010.

The net values derived from current direct use of the wild Atlantic salmon stocks, such as to anglers, are not included. Also, it is unclear whether the Canadian public as a whole would have been willing to pay more than currently to protect the status quo, Gardner Pinfold assumed that this would have been insignificant, in contrast to the study in England and Wales by Lawrence & Spurgeon (2007).

The choice survey in this Canadian study is also helpful in that it provides insights into why the public in eastern Canada value the Atlantic salmon.

The public's valuation of restored stocks of Atlantic salmon in Eastern Canada
The figure of 105 mCAD / m€113 (2019 adjusted) was a mid-point. The full conclusion of the report is "*There is over 80% public support in Eastern Canada for a sustained 20-year program with new annual investments of $53M - $157M* (annually) *that will "likely" or "very likely" restore Atlantic salmon abundance to 40% -80% of historic highs".* This is equivalent to m€40 – 118 today.

It is clear that the indicated value of Atlantic salmon to the Canadian public goes far beyond fishing. While 28 percent of the people surveyed had been fishing, that was any type of fishing and at any time in the past: so few were salmon fishermen. Nonetheless, more than 80 percent were willing to contribute annually to pay for a 20-year programme to restore stocks. It is likely that most of this comprises existence, bequest and option values. As noted by Gardner Pinfold (2011), much will be derived from '*an appreciation of species and nature generally and they* (Canadians) *assign significant value to efforts that address environmental concerns*.' They stress that this willingness-to-pay is expected to include broader benefits to ecosystems from conservation efforts aimed at salmon.

'The two top rationales for supporting wild salmon conservation were 1) that salmon should exist, 2) the importance of natural heritage and ecosystem integrity.'

In general, most people's willingness-to-pay for conservation measures was relatively small, averaging between 12 CAD and 40 CAD per year, but when summed across the whole population, about 4 million households, the total was substantial.

The influence of level of education
The survey indicated that only a small proportion of the public were familiar with issues affecting Atlantic salmon including the state of stocks, threats to salmon, government roles, and conservation measures.

The survey tested the impact of a limited briefing on Atlantic salmon issues that took about thirty seconds to read. Even this limited information, less than one page of text provided on a 'What's at stake' screen, increased people's willingness-to-pay for conservation measures.

The survey also indicated that public education will have additional benefits stimulating people to learn more about the Atlantic salmon and its conservation.

The likelihood of success
People's willingness-to-pay for or 'invest in' a programme of work to boost salmon stocks varied with the likelihood of it succeeding. Two categories were offered:

- 'Likely': 50%-80% chance of success
- 'Very likely': 80%-99% chance of success.

Willingness-to-pay was substantially greater if success was 'very likely' as opposed to 'likely'. This implies that the willingness-to-pay for guaranteed success would be greater still,

Total Economic Value in England & Wales (UK)
Key reference: Lawrence & Spurgeon (2007)

What was measured?

In contrast to the Canadian study (Pinfold Gardner, 2011), Lawrence & Spurgeon (2007) estimated the existing Total Economic Value (TEV) to the general public of England and Wales, as well as the potential for change. They surveyed 911 people to represent households in 23 locations across England and Wales using both choice experiments and contingent valuation to measure the public's willingness-to-pay. The more conservative results from the contingent valuation were adopted.

For the contingent valuation, the people surveyed were asked if their household would be prepared to pay towards protecting salmon stocks from severe decline (95 percent) due to disease and, if so, how much every year for 25 years. The scenario was chosen for two reasons:

- it is a close representation of the potential impact of *Gyrodactylus salaris*; and
- to concentrate respondents' minds specifically on wild Atlantic salmon rather than other aspects of river/ environmental quality.

The general public's valuation of existing stocks of Atlantic salmon in England and Wales

About two-thirds of the people sampled said they would be prepared to pay an additional sum to avoid a severe decline in salmon stocks in England and Wales generally. The average amount per household was 15.80 £ but there was a wide range. Assuming 1 £ = 1.20 € and adjusting for inflation from 2006 to 2019, this equals 22.5 €. Half of those surveyed were prepared to pay 5 £ / 7 € or less but five percent were prepared to pay 100 £ / 143 € or more per year.

The total extra willingness-to-pay for England and Wales to prevent a severe decline in salmon stocks was estimated as:

15.80 £ x 22.3 million households = 350 m£ /m€499 per year

Capitalised over 25 years, this extra willingness-to-pay would have a present value of about 6 billion £. These two figures, annual or capitalised, indicate the total economic value of 95 percent of the salmon stocks in England and Wales in 2006.

This TEV includes both use (such as fishing) and non-use values (notably existence and bequest values). However, as with the Canadian study, for most people, their willingness to pay had little to do directly with salmon fishing. The proportion of the population involved with salmon fisheries in England or Wales is very small. Though about 12 percent of the people surveyed had a family member who had been freshwater fishing in the previous year, very few would have fished for salmon. Only 30 000 licences were issued to fish for salmon in 2006, about 2 percent of the 1.3 million issued for freshwater fishing (EA, 2007).

There are two notable differences between this study and that in Canada (Gardner Pinfold, 2011), that is:

- It found a substantial (TEV) willingness to pay more to protect existing stocks, assumed to be negligible in Canada.
- The Canadian study intentionally included wider environmental aspects in the valuation whereas this UK study aimed to assess the wild Atlantic salmon in isolation.

Marginal changes in salmon stocks and loss aversion

The choice experiment explored willingness to pay for changes, both better and worse, in the abundance of salmon in a named river. Four levels of abundance were used: No salmon, Poor, Moderate, Good as shown in Figure 5.2.

These results suggest that even poor stocks of salmon would have been valued in a river which currently had none. A river with moderate stocks was valued three times as much as with poor stocks, while good stocks were four times more highly valued.

Substantial loss aversion was found, meaning that respondents were willing to pay significantly more (perhaps two or three times as much) to prevent a reduction in stocks, say from good to poor, than they would to achieve a comparable improvement in stocks, from poor to good. This is consistent with general observations on how people value gains and losses (Thaler and Sunstein, 2008).

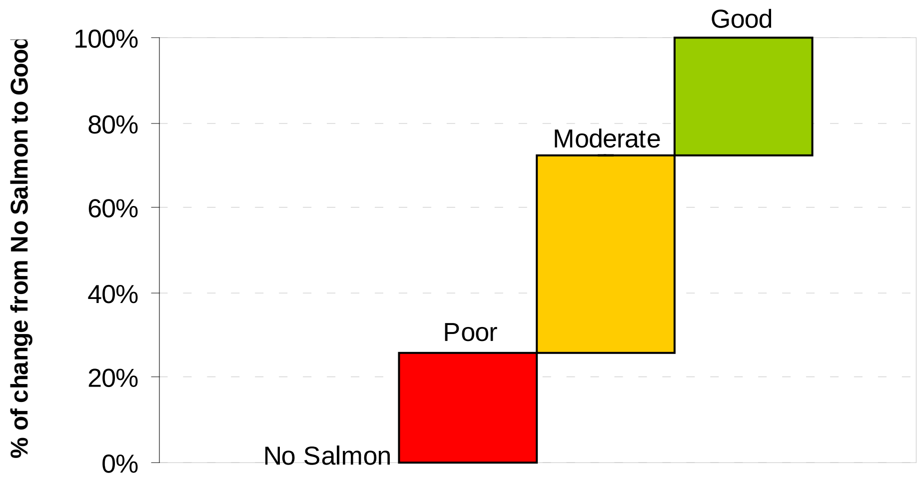

Figure 5.2. Willingness to pay for different levels of salmon abundance.

Other factors affecting willingness-to-pay for individual rivers

Some social factors tended to increase people's willingness-to-pay including wealth and background education level, and whether they went boating or fishing or had environmental concerns. It was also affected by:

River size: Longer rivers attracted a greater willingness-to-pay.

Distance from home: Willingness-to-pay declined up to 70 kilometres with the distance of the household from the river but remained constant beyond that. This implies that people in England and Wales care about salmon in rivers wherever they live though they place more importance on rivers nearby.

A salmon stock, of a given quality, in a river with a heavily populated catchment, such as the River Thames or the River Mersey, would therefore tend to be more highly valued than a similar one in a rural area.

Total Economic Value in Ireland

Key reference: IFI (2013)

What was measured?

The contingent valuation method was used to 'estimate values that the Irish public place on avoiding the deterioration in the quality of Ireland's natural fish stocks and angling experience in relation to the current situation without new policy.' This is therefore not a specific evaluation of salmon but of all natural fish and angling, though clearly that includes wild Atlantic salmon. As with the study in England and Wales (Lawrence & Spurgeon, 2007) it estimates the current Total Economic Value (TEV) rather than the benefits from an improvement in stocks, as in the Canadian study (Gardner Pinfold, 2011).

There were two surveys, one of households, the other of recreational anglers. The household survey was used to estimate the TEV, while the survey of anglers indicated the component of the TEV attributable to anglers.

The general public's valuation of natural fish stocks and angling experience in Ireland

Just under half (47 percent) of respondents in the household survey were willing to pay a positive figure towards the preservation of fish stocks and quality of recreational angling in Ireland. As expected, the proportion in the survey of anglers was greater, 66 percent.

After adjusting for socio-economic characteristics of the sample relative to the population as a whole, the mean predicted willingness-to-pay for the general population was 16 € per person per year. Of respondents to the household survey, 12 percent said they had fished in the past twelve months or were members of a fishing club. Their predicted willingness-to-pay was more than twice as much, averaging €37 per person per year. From the survey of anglers, the mean predicted willingness-to-pay was even higher, €66.5.

The total economic value of the angling resource to the Irish public (3.6 million people over 15 years old) was estimated to be m€58 per year. The equivalent figure for 406 000 active anglers using Irish waters, mostly Irish residents, each year was m€27 per year. This suggests that about half of the TEV of the natural fish stocks and angling experience was derived from current anglers.

Conclusions about the total economic value estimates of wild Atlantic Salmon

- In the countries studied, the general public as a whole values the status of stocks of wild Atlantic salmon over and above its use for fishing.
- For many households the value tends to be small but cumulatively across the population, it can be large.
- That value can be increased by public education, raising awareness of the wild Atlantic salmon and the factors affecting the future of stocks.
- Even people who live far from a salmon river may still value the species, though those living close by tend to value it more highly.
- Higher values may be placed on protecting good stocks than from improving poor stocks.
- Willingness-to-pay for a programme to improve stocks will be greater if it has high likelihood of success.

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5.1.2 The sale price of commercially caught salmon

Country: Scotland (UK)

Purpose: To illustrate variations in the sale price of wild Atlantic salmon in relation to the catch and the increasing availability of farmed salmon from 1978 to 2016.

Introduction

The gross value of commercially caught salmon is basically a function of the weight of the catch and the price per unit weight. Commercial production of farmed salmon has grown exponentially since the 1970s offering, in most countries, a ready substitute for wild salmon as food. Production of farmed salmon in the North Atlantic area in 2017 was 1624 tonnes, more than a thousand times the total catch in fisheries of 1182 tonnes (ICES, 2018). If farmed salmon is perceived as a close substitute for wild salmon, the price of wild salmon would be expected to follow that for farmed fish.

What was measured?

The Fishmongers Company recorded the monthly prices for fresh Scottish Atlantic salmon, farmed and wild, sold at the at the Billingsgate fish market in London. To avoid seasonal variation, the prices in one month, August, are used to demonstrate long-term trends, these are shown in Table 5.1 adjusted to August 2018 prices using the Retail Prices Index (ONS, 2019).

How have prices changed?
As shown in Figure 5.3, the price in August of farmed Scottish salmon declined fairly steadily in real terms from a peak in 1979 of almost £25/kg, to £3.6/kg in 2003 (conversions to € not possible). Since then it has risen slightly, remaining around £5/kg.

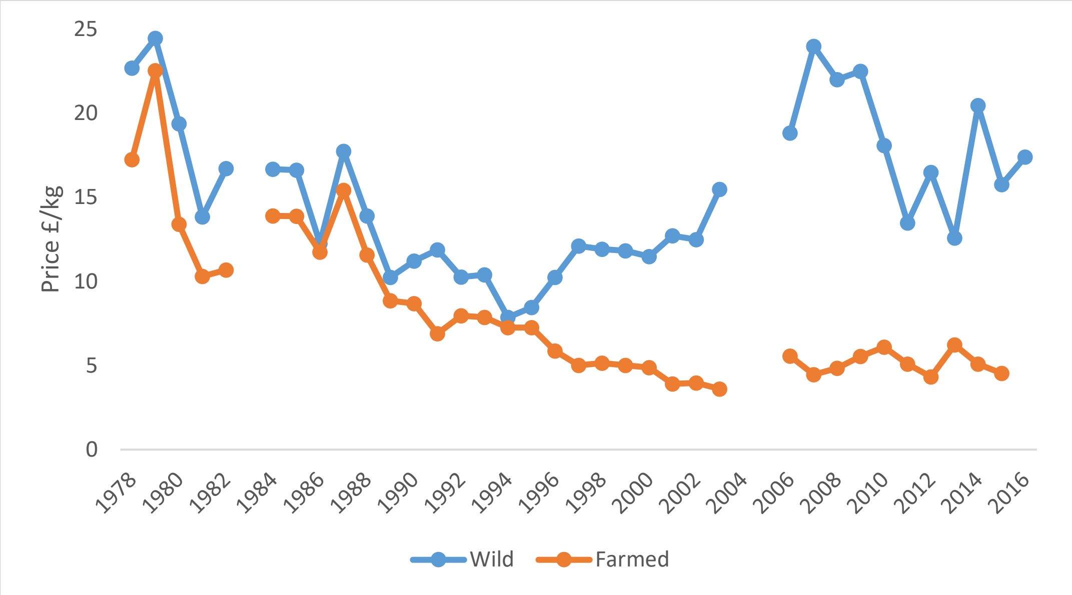

Figure 5.3. The prices of wild and farmed Scottish salmon recorded by the Fishmongers Company at Billingsgate from 1978 to 2016, adjusted by the Retail Price Index (ONS, 2019) to 2018 prices.

Despite falling catches of wild salmon in Scotland (ICES, 2018), the price of wild salmon followed suit, albeit with a premium, until the late 1990s. For the next few years, the salmon farming industry received negative publicity on a range of issues, including potential risks to human health and the environment, and the eating qualities of farmed salmon (e.g. Reichart, 2000; Charter, 2001; English & Young, 2001; Millar 2001; Girling, 2001; Brown 2004; Henderson, 2004) reflecting published science (e.g. Jacobs et al, 2002; Hites et al, 2004). There was a correlation between the price of wild salmon and farmed salmon over the entire period (n=35, d.f.=33, F=4.1, r^2=0.11, P=0.05). From 2000 to 2015, the price of wild salmon was not significantly correlated with that of farmed salmon (n=14, d.f.=12, F=0.42, r^2=0.03, P=0.53) and returned to the level recorded before farmed salmon became widely available. In this century, wild salmon would therefore seem to be viewed as a discrete product. Its price is negatively correlated with the annual Scottish catch of salmon by net and traps (n=15, d.f.=13, F=5.2, r^2=0.28, P=0.04) given in Table 5,2. Note that we do not convert the values to € in this analysis, as the time series predates the beginning of € as a currency. From 2009 to 2019 the average exchange rate was 1 £ = €1.20.

Knapp et al. (2007) noted a similar pattern in the price of wild troll-caught chinook salmon with a steep rise after 2003; before that wild chinook and fresh farmed Atlantic salmon were considered close substitutes. They also suggest that negative publicity was a factor driving the change, as well as wild salmon marketing efforts and growth in total market demand. There was a difference in timing, however, as this rise started later than at Billingsgate.

The impact of price on the gross value of the commercial catch
Insofar as the price of salmon sold at Billingsgate in August is an index of the average annual price obtained by commercial fisheries in Scotland, Figure 5.4 indicates that the later higher prices helped sustain the gross value of the fisheries, at least until 2014. Although the average

net and trap catch in the period 2008-2014 was 35 percent lower than for 1997-2003, the average gross value of the catch was only down by 10 percent.

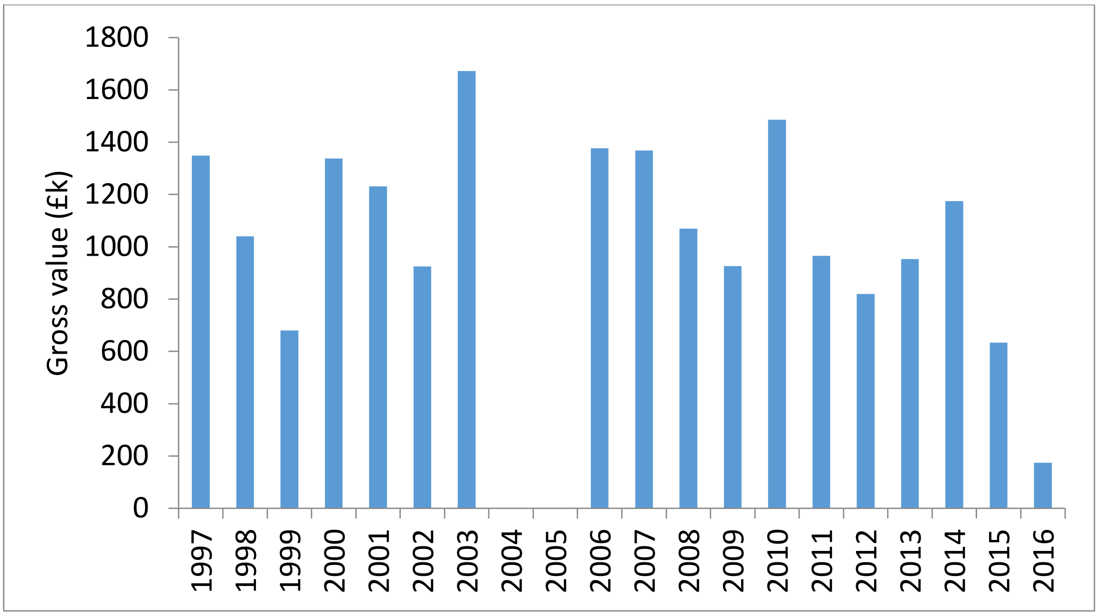

Figure 5.4. The gross value (£k) of the catch in Scottish net and trap fisheries as indicated by the August price at Billingsgate fish market.

Conclusions

- The increased availability of farmed salmon initially reduced the value of the Scottish catch of wild salmon.
- Following negative publicity for farmed salmon, wild Atlantic salmon became a discrete, higher value product. Prices for wild salmon rose as catches fell, helping to sustain for a while the gross value of the catch.

Table 5.2. The prices of wild and farmed Scottish salmon sold in August at Billingsgate Fish Market, London (Fishmongers Company, pers. comm.); the production of Scottish farmed salmon from 1978-2016 (ICES, 2018; Munro & Wallace, 2018); the net and trap catch (tonnes) in Scotland (Marine Scotland, 2018); and the calculated index of the gross value of the net and trap catch from 1997-2016.Values in Euros added after 2009 at the average conversion rate of 1 £ = 1.20 EUR.

Year	Wild price per kg (£/€)	Farmed price per kg (£/€)	Scottish farm production (t)	Net & trap catch (t)	Value of net & trap catch (in 1000 £/€)
1978	22.7	17.3	*		
1979	24.5	22.5	*		
1980	19.4	13.4	598		
1981	13.8	10.3	1133		
1982	16.7	10.7	2152		
1983	*	*	2536		
1984	16.7	13.9	3912		
1985	16.6	13.9	6921		
1986	12.3	11.8	10337		
1987	17.8	15.4	12721		
1988	13.9	11.6	17951		
1989	10.3	8.9	28553		
1990	11.2	8.7	32351		
1991	11.9	6.9	40593		
1992	10.3	8.0	36101		
1993	10.4	7.9	48691		
1994	7.9	7.3	64066		
1995	8.5	7.3	70060		
1996	10.3	5.9	83121		
1997	12.1	5.0	99197	111.3	1348
1998	11.9	5.2	110897	87.3	1040
1999	11.8	5.0	126686	57.5	680
2000	11.5	4.9	128959	116.5	1338
2001	12.7	3.9	138519	96.8	1231
2002	12.5	4.0	144589	74.0	925
2003	15.5	3.6	169736	107.9	1672
2004	*	*	158099	86.4	*
2005	*	*	129588	88.3	*
2006	18.8	5.6	131847	73.1	1377
2007	24.0	4.5	129930	57.0	1368
2008	22.0	4.8	128606	48.5	1069
2009	22.5 / 27.0	5.5 / 6.6	144247	41.2 / 49.4	927 / 1112
2010	18.1 / 21.7	6.1 / 7.3	154164	82.1 / 98.5	1485 / 1782
2011	13.5 / 16.2	5.1 / 6.1	158018	71.6 / 85.9	966 / 1160
2012	16.5 / 19.8	4.3 / 5.2	162223	49.7 / 59.6	820 / 984
2013	12.6 / 15.1	6.2 / 7.4	163234	75.7 / 90.8	953 / 1144
2014	20.5 / 24.6	5.1 / 6.1	179022	57.4 / 68.9	1174 / 1409
2015	15.8 / 19.0	4.5 / 5.4	171722	40.2 / 48.2	633 / 760
2016	17.4 / 20.9	*	162817	10.0 / 12.0	174 / 209

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5.1.3 Maintaining cultural connections with salmon in modern management

Countries: Canada, Finland, and Norway

Purpose: To illustrate the cultural values linked to wild Atlantic salmon, highlighting and discussing the challenges of maintaining the biological resources and cultures in context.

Atlantic salmon in Sápmi
For millennia, fjords and rivers along the North Atlantic coastline have sustained local and indigenous communities with returning salmon, making salmon an integral part of these communities' culture, identity, diet, economy, social relations and spiritual practices. The historical importance of the salmon has resulted in a great variety in salmon fishing techniques, knowledges and values directly related to the fish itself such as various harvest methods, processing and conservation, exchange and trade. The salmon has thus formed, and still forms, social networks connecting technology, social and managerial organization and cultural practices, varying through time and space.

Among the most productive Atlantic salmon rivers globally is Deatnu/Tana/Teno, a major river in Sápmi (land inhabited by Sámi people) that forms the border between Norway and Finland. In Sámi, 'Deatnu' means "the big river", and its salmon stocks have been of fundamental importance for people to make a living in the arctic river valley. Furthermore, salmon formed the basis for the Deatnu River Sámi culture and economy (Holmberg 2018) and is still highly valued. Here, relational, cultural, social, linguistic, and narrative aspects of human-salmon practices still form parts of everyday life. Today, Deatnu is one of the very few salmon rivers in Norway where net and trap fishing is still legal. During the summer fishing season, even people that do not fish themselves gather by the Deatnu shore to watch the traditional net, boat or rod fisheries. They light bonfires, make coffee, grill freshly caught salmon and talk about the conditions of the river and compare this years' salmon catches with previous years (Joks 2016). When the fishing season ends, pieces of salmon have been smoked, salted or frozen for exchange, sale or own consumption during the following winter; nets are repaired, wobblers are made and new flies are tied; and conversations go as preparations are made for the next season (Ween 2012).

While the salmon fishery no longer provides the same level of livelihood sustenance among the Deatnu valley inhabitants as it used to do, the salmon is highly valued for its contribution to quality of life and social relations, local identity and sense of place, continuity of traditions, mental and physical health, cherished meals and the stories they bring along, as well as how the salmon contributes to maintaining and developing indigenous and local knowledge (Joddu 2018). As such, the salmon is considered central in maintaining the settlement and the Sámi language along the entire Deatnu valley. People locally emphasize the excitement connected with waiting for and observing the salmon and taking part in the fishery. They also highlight how they observe nature throughout the year, as they look for signs to tell if the salmon season will be good or bad. Maintaining and passing on practices and knowledges related to reading the signs of the river and salmon behaviour, fine-tuning fishing gear, and processing the catch are also considered significant (ibid.).

Furthermore, the importance of the salmon over a long period of time, has led to salmon-related knowledges expressed in detailed terms and language (Joddu, 2018). Language and culture are closely connected: "Together with the words for objects and phenomena, we learn our culture's connotations, associations, emotions, and value judgments. The definition and construction of our ecosocial world, including group identity, status, and world view, are reflected in, reflect on, and are realized through language" (Skutnabb-Kangas 2001: 398-399). Among Deatnu inhabitants, fishing is also about entering a relationship with the salmon. The Sámi word *bivdit* means, on the one hand, to fish or hunt, and on the other hand, it means to ask, for instance, someone to do something. *Bivdit* or fishing therefore means asking for a catch, illustrating the relational human-salmon aspects involved in this fishing (Joks, 2015, Joks & Law, 2017).

In Deatnu, international guidelines from NASCO, a bilateral agreement between Norway and Finland, national regulations and regional and local management arrangements, all intervene with traditional Sámi fishing practices and other salmon-related activities carried out along the watercourse. In addition to Norway's particular responsibility for salmon conservation, it is also the responsibility of the authorities to "create conditions enabling the Sámi people to preserve and develop their language, culture and way of life" (Regjeringen.no). Combining these responsibilities have so far proved challenging in Deatnu. For several years, biological assessments of the Deatnu salmon stocks have evaluated most of these stocks to be of poor status (Anon. 2018), and the authorities' increasingly strict regulations on the length of the fishing season and permitted fishing gear have caused strong Sámi opposition (Holmberg, 2018). As the reductions in fishing and retention are found by some to erode Sámi practices and ways of living (Joks and Law, 2016), locals are calling for a management regime that is compatible with the maintenance and continued development of Sámi fishing traditions and knowledges (Holmberg, 2018). In other words, there is a local desire for also taking cultural values into account.

Traditional net trap fishing for salmon in Tana river. Photo: Børre K. Dervo

The challenge of co-management – federal, provincial, and aboriginal perspectives in Nova Scotia

A somewhat similar situation can be found in the Atlantic province of Nova Scotia, Canada, where declining salmon stocks have prompted conservation measures set by the federal Department of Fisheries and Oceans (DFO) and the provincial Nova Scotia Fisheries and Aquaculture. These measures include changes in angling regulations (e.g. catch-and-release vs. retention fishing), season lengths, and bag limits with the purpose of conserving salmon stocks from further declines and extinction. For Western societies, conservation regulations are widely regarded as the proper management response to any declining resource base. For species of special concern and subject to federal assessment, such as Atlantic salmon in Canada, there is increased scrutiny which call for decisions founded on data-driven evidence, i.e. based on stock assessments and in-season status reviews. However, it is exactly the meaning of *conservation* that causes a conflict with the Mi'kmaq's view, as it is perceived as too narrowly focused on single-species management and does not take other interests into account when setting harvest regulations (Denny & Fanning 2016).

The Mi'kmaq people is a recognized indigenous people group in Canada, closely tied to Mother Nature with a seven-generation perspective (Denny & Fanning 2016). Salmon, or *plamu* as it is known to the Mi'kmaq, are one of many animals that historically contributed to Mi'kmaq sustainability. Salmon were a staple food that was dependable, predictable, and could be found in most rivers in Nova Scotia. Today, because of a lack of abundance and concern for local populations, it is often reserved for special occasions such as ceremonies (Parenteau 1998 *in* Denny & Fanning 2016). As with the Sámi, the Mi'kmaq fear the loss of traditional knowledge and important cultural values as a result of the declining salmon populations and the conservative harvest regulations imposed upon the fishery. They have both Aboriginal rights and treaty rights. The right to fish for food, social, and ceremonial needs is an Aboriginal right, while the right to fish for a moderate livelihood is a treaty right. Both Aboriginal rights and treaty rights are recognized and affirmed by the Constitution Act and, as such, puts Canada's Aboriginal people "in a different legal relationship to the fisheries than non-Aboriginal Canadians" (Harris & Millerd 2010). The rights – and the relationship between them - were tried and reaffirmed in three court cases in the 1980s and 1990s (Denny & Fanning 2016). The Supreme Court further argued that "the burden of conservation measures should not fall primarily upon the Indian fishery" (R. v. Sparrow, 1990, p. 115).

However, the use of traditional knowledge encompasses both assessment, management, and conservation within the worldview of the Mi'kmaq, and is not easily compartmentalized into sections for comparison with the "Western" perspective (Denny & Fanning 2016). For example, the Mi'kmaq do not believe it is - and should be - necessary to distinguish between grilse and multi-sea-winter salmon. Traditionally, Mi'kmaq governance was a "*complex system of territorially defined relations and responsibility, multilevel governance, ethics and law that was and remains an effective means of managing a people, a territory, and the relationship with other beings*" (Ladner 2005). From a management perspective, the Mi'kmaq strive to fish for balance. This balance is not only relevant to achieving a balance in nature; "*it reflects a fishery that is balanced in spirit*". The Mi'kmaq believe that salmon fishing is reciprocal and that selection of grilse over multi-sea winter salmon is not always possible (Denny & Fanning 2016).

Further, Denny & Fanning provide the following explanation of Mi'kmaq perspectives on salmon conservation: "*Mi'kmaq are in general agreement that salmon populations have been in decline and there are certain rivers in which there is concern for its populations. The application of the English word "conservation" to salmon is confusing as salmon are still observed in many places… Scientific assessments are met with skepticism because many Mi'kmaq have their methods for assessing and managing salmon based on traditional knowledge. For the Mi'kmaq, it is the initial quantity of salmon in the pool that determines whether or not salmon will be removed and, if present, how many. Only a certain number of salmon will be harvested from a pool and, once fished, the pool will not be fished again that season*" (Denny & Fanning 2016).

Denny & Fanning aptly pose the following question, which sums up the ideological differences over a shared problem: "*How do groups move forward to reconcile perspectives and still retain values of conservation, the need for consumption, and recognition of the spirituality and cultural identity through salmon harvesting*?" From the Sámi and the Mi'kmaq cases it is evident that there would not necessarily exist a confrontation between the worldviews if the salmon populations were abundant; the problem and the conflict arise due to different ways to handle the declining resource and the increased demand. However, reality is that the resource is declining, although there exist some differences the view of the magnitude of the decline. Moving forward, how does one solve the ultimate problem of population declines and erosion of cultural connections with salmon?

Jentoft et al. (2009) suggested that a solution-based approach is not always possible, or even preferred, when dealing with such complex and radically different ways of being, knowing, and interacting. However, if solutions don't exist without compromising one worldview or ideology in favor of another, how do we save vulnerable and highly valuable wild salmon and salmon cultures? Such "wicked" problems (Jentoft et al. 2009, Jentoft & Chuenpagdee 2009) needs careful attention and all stakeholders should strive for better ways to handle them. Consultation processes resulting from conservation measures have provided an arena for indigenous people to be heard. Denny & Fanning (2016) suggest that the consultation process must be combined with other modes of participation; otherwise, there is no assurance that concerns and ideas will be influential in the decision-making. As a step further in the direction of increased tribal participation, co-management approaches provide the arena for the process of sharing insights and concerns in designing ways to reach a shared goal. Examples of this approach exist in forms of natural resource management, for instance in California, where the Karuk Tribe co-manages the forest with the United States Forest Service. Co-management is often preferred over increased impacts through consultation as it facilitates more constructive and collaborative decision-making processes (Diver, 2016).

Conclusion

The studies of the cultural values of wild Atlantic salmon show that loss of biodiversity and the lack of harvestable surplus directly leads to the loss of culture, practices and local knowledge related to salmon. Active practice is a necessity to let the knowledge not only survive but also develop and adapt. The possibility to continue local practices is therefore a key premise, and the conservation of local knowledge and practice in a historical or museal setting is not a sufficient approach. If local knowledge and culture is to survive, it needs to be practiced (Gómez-Baggethun & Reyes-García 2013), but it is ultimately contingent on the continued abundant presence of the resource. Pretty et al. (2009) argues for a combined approach to natural resource management which addresses biological and cultural diversity:

The degree to which biological diversity is linked to cultural diversity is only beginning to be understood. But it is precisely as our knowledge is advancing that these complex systems are under threat. While conserving nature alongside human cultures presents unique challenges, we suggest that any hope for saving biological diversity is predicated on a concomitant effort to appreciate and protect cultural diversity.

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5.2 Changes in use and/or values

Country: Canada (Newfoundland and Labrador)

Purpose: Social acceptance for management regimes, underlying power relations and unintended impacts on distributive justice

5.2.1 Response by anglers to shifting management regimes

Introduction
A common saying is that "managing fish is really about managing people". In so doing, understanding how different management regimes affect satisfaction and participation rates among different groups of anglers is important, because it has direct consequences for catch, effort, catch-per-unit-effort, and fishing mortality, as well as for the distribution of the social values of salmon angling. A recreational fishery on the Harry's River in Newfoundland, Canada, provided an opportunity to study the effects of four different management regimes on catch, effort, and mortality as well as participation among angler groups. The study was published in 2018 by Veinott, Pike, and Variyath in the North American Journal of Fisheries Management, and forms the basis for this case study.

What was measured
In this case study we were interested in understanding how management affects participation rates among angler groups; which effects different types of anglers have on Atlantic salmon mortality; and which factors are considered in decision processes.

The Harry's River Fishery
Atlantic salmon stocks in Canada have declined dramatically in the last decades, and many are at risk of extirpation (COSEWIC 2016). Angling is one of the most important direct causes for mortality in Atlantic salmon in Canada (ICES 2016), which makes harvest regulations a logical and potentially impactful management action. Commonly, managers respond to declining stocks by instituting a more restrictive harvest regulation such as bag limits and size limits. This is an overall effective measure in a consumptive fishery, but still causes some mortality if effort is not sufficiently regulated (van Poorten et al. 2013). When bag limits are imposed or become more restrictive, it is certainly effective in reducing the impacts of skilled anglers, but most anglers do not meet their bag limit. In other words, the bag limit only affects a small proportion of anglers in many cases. When bag limits are reduced to zero, but angling is still permitted (through catch-and-release regulations), there will still be some fishing-induced mortality, as C&R inevitable causes some hooking mortality (van Poorten et al. 2013). Bag limits are effective in deterring consumptive anglers (Cox et al. 2002), whereas bag limits of zero may potentially attract more C&R anglers.

A recreational fishery on the Harry's River in Newfoundland, Canada, provided an opportunity to study the effects of four different management regimes on catch, effort, catch-per-unit-effort, and mortality, as well as participation among angler groups. Veinott et al. (2018) studied the process of adaptive management that went against most fisheries management practices. Veinott et al. (2018) wrote the following about the changes in management regimes in the fishery:

"F*or Harry's River on the island of Newfoundland, NL, Canada, a different management approach was taken. After 6 years of catch-and-release angling on Harry's River, with no improvement in the number of returning Atlantic Salmon, fisheries managers within DFO reopened Harry's River to retention angling. Prior to taking this action, DFO organized a meeting with concerned anglers from the Harry's River area and heard that local anglers were not participating in the salmon fishery because they were primarily consumptive or retention anglers and were not supportive of the catch-and-release-only policy. They believed that this led to non-compliance in the angling community as well as exposing the salmon stock to an illegal, commercial-scale* *fishery. The anglers argued that by allowing a retention fishery, the number of anglers using the river would increase, thus making it more difficult for any illegal fishing to take place and, by extension, leading to improvements in returns. These claims were neither confirmed nor refuted by DFO. Nevertheless, based on this input, DFO reopened Harry's River to retention angling beginning in 2003*." (Veinott et al. 2018 p. 211).

Prior to the study, there were few assessments of the impacts of different harvest regulations in Canada. However, Veinott et al. (2013) found that salmon anglers in Newfoundland shifted their efforts to rivers with the highest bag limits or least restrictions, and that fewer than 5% of anglers reported releasing their entire catch. This suggests that the anglers in the province are primarily consumptive.

In the analysis there were four different management regimes (MR) from 1997 to 2015. These were 1) catch and release only (1997-2002); 2) catch and release at the start of the season, with allowed retention after an in-season review of stock status (2003-2006); 3) retention angling for the whole season, with a fixed bag limit (2007, 2009, 2012, and 2013); and 4) retention angling for the whole season, with an increase in the bag limit after an in-season review of stock status (2008, 2010, 20111, 2014, and 2015). Details on the length of each season and the specific bag limits can be found in Veinott et al. (2018).

Fisheries statistics during the management regimes
The number of returning spawners declined during the first management regime, but has since then shown an increasing, albeit erratic trend (Figure 5.5). During the entire study period the mean angler effort was consistent around 3 days per angler per year, with somewhat higher effort in the early years of the series (4 days annually). The mean annual catch rate declined from 3.6 salmon per angler in the first period to less than 2 salmon per angler in the last period.

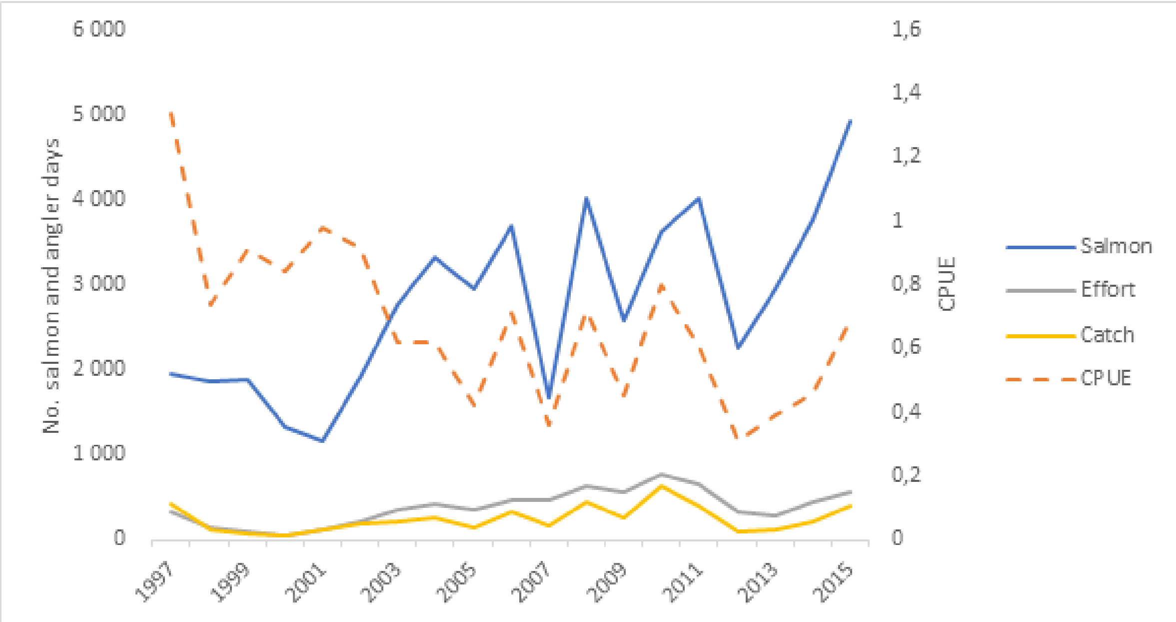

Figure 5.5. The number of returning adults to Harry's River, total number of fish caught, and total number of angler days from 1997 to 2015 (left vertical axis), and the associated mean CPUE during the angling season (total number of fish caught divided by total number of angler days; dashed line, right vertical axis). The figure is based on data from Veinott et al. (2018).

The proportion of anglers in the province that reported fishing in the Harry's River increased in 2003 when the fishery lifted its ban on consumptive angling (to 2.8% of all license holders in NL). Most often a fishing trip ended in zero catch (60% of rod-days) and 25% of fishing trips yielded one salmon. C&R anglers were the most likely to fill their daily bag limits (22% of C&R anglers).

Across all years, catch and effort were strongly correlated, whereby effort alone could explain 79% of the variation in catch (Veinott et al. 2018). The CPUE was greatest under the catch-and-release only management regime. This was also the time when returns were the lowest. Veinott et al. (2018) attributed this to the C&R fishery attracting highly skilled anglers who were able to catch salmon despite low numbers of fish in the river.

Management and values
In a single fishery it is difficult to discern cause from correlation and effect from coincidence and determining whether the management regimes had an effect on the number of returning adults the following generation is highly uncertain. The number of fish available (both present in the river and available for retention) drives the number of anglers but determining whether the management regime affects the number of fish in subsequent years is tentative. In terms of participation rates, the management regime clearly had an effect on the Harry’s River fishery. By relaxing regulations (but still maintaining a small bag limit) participation rates among retention-oriented anglers increased substantially. Effort and mortality rates generally increased, and CPUE generally declined (Veinott et al. 2018). As noted above, adjustments in management regimes do not necessarily imply causation in the returns of Atlantic salmon to the Harry’s River, perhaps with management regime (MR1) as an exception. Assuming that juveniles outmigrate at age 2 or 3 and return as adults after 2 winters at sea, low mortality rates among the few returning adults in 1997-2002 (MR1) likely had a positive effect on the returns 4 to 5 years later.

Interestingly, the regulations were relaxed despite continued declines in the number of returning adults (moving from MR1 to MR2). Compared to typical fisheries management practices in the last decades, this is an unorthodox response to a declining resource. The decision to relax the regulations could owe to a strong belief that the low mortality rates for several years would produce a sufficiently positive effect on returns in coming years to warrant a different management regime. However, also the apparent lack of results of the C&R regime, a worry that fewer local anglers keeping an eye on the river could lead to increased levels of poaching, and incidental mortality from C&R fishing practices were the driving forces behind the decision to change management regimes. In discerning which of these factors were likely more important in the decision to change the management, the following figures can be useful: Mortality rates (including known mortality plus a 10% C&R mortality multiplier) averaged 0.9% of the returning adult population during MR1, grew to 2.3% during MR2, 3.1% during MR3, and 4.6% during MR4 (Table 1 in Veinott et al. 2018). This suggests that the worry for poaching by having fewer fishermen on the river, must have made quite a strong case for shifting the management regime. Furthermore, from the description in the introduction there were indications that angler satisfaction – and primarily the satisfaction of consumption-oriented segment of anglers – was a primary concern in this fishery. Maintaining angler satisfaction was therefore probably another important deciding factor in relaxing the regulations.

Listening to the anglers is an important aspect of fisheries management. The angling population is, however, a diverse group, and the wishes by the various segments must be weighed against what is biologically defensible. Additionally, the laws that govern access to fishing vary between countries and set the terms for which management actions are legally and practically possible. A main pattern that has emerged in recent decades, often in response to high angling pressure and declining salmon populations, is the increased use of C&R in jurisdictions where access to fishing can also be regulated (i.e. private fishing rights typical of Europe). This has been met by opposition by harvest-oriented anglers, often on principal and ethical as well as using arguments related to justice and equality. Øian et al. (2017) studied disagreements over management strategies and angling practices among salmon anglers in the Orkla River, Norway. The changes in management regime followed in the wake of the declining salmon returns, prompting increasingly strict harvest regulations and a shift towards a C&R fishery. A key finding in their study was that different groups view the ultimate threats to salmon populations in quite different ways. These views appeared to “*originate in rather complex patterns with respect to the ways stakeholders related to and engaged with salmon, rivers and nature in general*” (Øian et al. 2017). Øian (ibid.)

noted that although the effects of regulations on angler behaviour and satisfaction have been studied extensively, "*less attention has been paid to how controversies, which often follow in the wake of these kinds of measures, tend to involve issues that reach far beyond the angling practices in themselves, by including, e.g. political, cultural and moral dimensions of societal relationships with nature*".

Conclusions

The Harry's River case reflects a situation where managers tried to satisfy a diverse group of anglers by listening to locals instead of continuing a generic biology-driven management regime that did not seem to halt the salmon declines on the short term. This way, the management were able to fulfil a wider set of angler segments' preferences and probably provided an overall larger set of social benefits.

In jurisdictions that are not limited by access, such as in Canada and the United States, there has been a tradition for allowing catch-and-release angling on declining populations. This has excluded harvest-oriented anglers, which in some areas constitute a large portion of anglers. Management regimes that permit harvest of one or a few fish per season benefit from knowing who participates under the various regulations and can maintain angler satisfaction amidst low returns.

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5.3 Salmon rivers, reborn

Countries: United States, France, Denmark, England (UK) and Norway

Purpose: To illustrate benefits from the restoration of stocks of Atlantic salmon

5.3.1 Barrier removal as a measure to restore salmon populations

Countries: United States and France

Purpose: Identify the drivers and mechanisms behind decisions to remove dams, and if available, cost-benefit data.

There has been a rapid increase in barrier removals on rivers of the Northern Hemisphere over the last two decades as a result of stricter environmental regulations. The purpose is in many cases to restore and expand the abundance, spatial distribution, and life history diversity of migratory fishes that were lost when the dams were constructed. Most of the dams that have been removed were small (<10m) and obsolete, but notable exceptions exist. Within the range of Atlantic salmon, the most prominent large-dam removals were undertaken on the Penobscot River in Maine, United States, and decommissioning is currently underway on the Sélune River in Normandie, France.

What was measured?
We use the work by Opperman et al. (2011) to review the processes leading up to the decision to remove two dams on the Penobscot, with an emphasis on highlighting the changing perceptions of free-flowing rivers and how this shaped the dam relicensing process. We then present a case from the Selune River in France to give European perspective on dam removal as a measure to restore salmon in a largely imperilled section of its range.

The Penobscot River: shifting priorities in dam relicensing processes
The 22 000 km^2 Penobscot River basin is the largest in Maine and second largest in the Northeastern United States. It encompasses over 8800 km of mainstem and tributary habitat, which historically supported great populations of diadromous fishes. The fish resources were important to the native Penobscot Tribe and to the early European settlers. Historical accounts indicate American shad (*Alosa sapidissima*) runs in excess of two million fish annually, followed by Atlantic salmon with runs prior to 1830 exceeding 100,000 fish (Atkins and Foster 1869). The ranges of the diadromous species in the Penobscot watershed varied, with Atlantic sturgeon (*Acipenser oxyrinchus*), Rainbow smelt (*Osmerus mordax*), Atlantic tomcod (*Microgadus tomcod*), and sea-run brook trout (*Salvelinus fontinalis*) all likely restricted by a natural fall (where Milford Dam is currently located), whereas other species migrated significantly further upstream to the many headwater streams (Saunders et al. 2006, Opperman et al. 2011).

Dams were constructed on the Penobscot main stem starting in the 1820s. The dams were located just above head of tide and in the current locations of the Veazie, Great Works, and Milford dams, thus blocking passage to migratory fish spawning and rearing grounds. By 1837, more than 250 sawmills were active on the mainstem and the tributaries (Atkins and Foster 1869 in Opperman et al. 2011), and agricultural and industrial development in the watershed severely polluted the water (Opperman et al. 2011). By 1868 the shad returns were reduced to some 5000 fish, and salmon were functionally extirpated (Atkins and Foster 1869 in Opperman et al. 2011). Most non-federal dams in the United States are regulated by the Federal Energy Regulatory Commission (FERC). FERC issues 30-50 year licences, and dam owners must apply to relicense operation before the licence expires. Because of the relicensing process, different considerations may be taken from one period to the next. Notably, the Clean Water Act (1972) and the Endangered Species Act (1973) came into effect since the issuing of the previous licence (Echeverria et al. 1989). The Electric Consumers Protection Act of 1986 (ECPA), an amendment to Section

4(e) of the Federal Power Act of 1935, required FERC to give “equal consideration” to conservation and recreational uses of rivers alongside hydropower production. Through the ECPA, Congress directed FERC to provide a greater balance within licensing processes between energy production and recreational and environmental resources (Gillilan and Brown 1997). Federal resource and regulatory agencies can exercise conditioning authority during licensing processes, whereby they can set conditions that FERC must incorporate into a new licence. Conditions include fish passage requirements or mitigation of problems caused by the continued operation of a dam.

Relicensing is now generally pursued through the Integrated Licensing Process (ILP). ILP strives to more effectively incorporate state and federal agencies and stakeholders, such as conservation groups and recreational NGOs, into the relicensing process. Through the ILP, FERC now encourages relicensing processes to culminate in settlement agreements, which are legally binding agreements that are negotiated and signed by a licensee and signatories such as tribal nations, state and federal agencies, and NGOs (Opperman et al. 2011). The process allows for taking a comprehensive approach to relicensing rather than piecemeal decisions that can be litigated in isolation. Opperman et al. (2011) list three main factors that facilitated a comprehensive approach to the relicensing process on the Penobscot. First, in the 1980s, proposals to erect new dams and applications for relicensing existing dams led to divisive processes between stakeholders. Secondly, all the hydropower installations on the lower Penobscot were consolidated into one owner (PPL Corp.) in 1999 following deregulation of the electricity market. Finally, the Penobscot Indian Tribe was recognized as a sovereign tribe, requiring the federal government to exercise its trust responsibilities to ensure proper management of natural resources on tribal lands, hereunder access to fish and fishing. The consolidation of ownership and the Tribes’s improved legal status paved the way for a comprehensive approach to balancing hydropower and fish in the Penobscot River basin.

In 2004, the parties filed with FERC the Lower Penobscot River Comprehensive Settlement Accord, a multiparty legal agreement designed to reconfigure hydropower production on the lower Penobscot system. The goal was to both restore migratory fish populations while maintaining hydropower production under new licences at PPL’s dams (Opperman et al. 2011). Under the agreement, PPL granted a five-year option to purchase three dams (Veazie, Great Works, and Howland) to the newly created not-for-profit Penobscot River Restoration Trust for 25 M USD. The Trust was composed of the Penobscot Indian Nation and the five conservation NGOs involved in the negotiation. The Trust’s plan, which was approved, was to decommission the Great Works (2012) and Veazie (2013) dams, improve passage at Howland Dam (2016), and to increase generating capacity at remaining dams in a way that more than compensated for the loss. The Veazie and Great Works dams had the largest detrimental impacts on the shortest migrating species because they blocked passage. By removing these dams, and increasing passage capacity at Howland dam, diadromous fishes had access to an estimated 6893 km of stream. In 2018, 750 Atlantic salmon, 3923 American Shad and over 2 million alewives made it to the Milford Dam fish lift.

The return of anadromous fishes represented the closing of a long hiatus for the Penobscot people, whose culture and livelihood evolved around bountiful runs of numerous diadromous species. Because they view the river and its resources as a gift from the Creator, many members of the Tribe see the restoration project as an act of reciprocity that contributes to the partial restoration of historic conditions and resources (Opperman et al. 2011). Direct economic benefits of the project were estimated to include almost 200 short-term construction jobs, which were predicted to add approximately 8 M USD to the local economy (FERC 2010). For a county that ranks poorly relative to the nation average, these were positive economic effects.

The Sélune River
Just like in the United States, the rate of dam removals is also on the increase in Europe but the regulations prompting the removals differ. In the European Union, the Water Framework Directive (2000/60/EC) serves as an overarching standard for water quality and biological integrity of all waters. The Directive states that all water bodies should achieve good ecological status by year 2027 which is a lofty target considering the vast number of dams on the continent (estimated at 0.6-1.8 million; Garcia de Leaniz 2008) and long history of flow manipulation. A directive is a legal act of the European Union which requires member states to achieve a particular result without dictating the means of achieving that result. It can be distinguished from regulations, which are self-executing and do not require any implementing measures. Member states have therefore implemented the Water Framework Directive through statutes or laws, hence integrating the Directive into national legislation. National and local laws set forth additional requirements, which differ among and within member countries, but whose practices and interpretation need to comply with the goals stated in the Directive.

In France, dams contributed significantly to the extirpation of Atlantic salmon in most large river systems and currently limit the distribution of anadromous salmonids generally to the lower reaches of small coastal streams (Forget et al. 2018). On the Sélune River in Normandie, two large hydroelectric power dams (La Roche-qui-Boit, 16m high and 125m wide; Vezins, 36m high and 278m wide) constructed in 1916 and 1932, respectively, effectively blocked access to most of the historically important watershed. Despite the detrimental effects of the dams, the Selune still is the third-most abundant salmon river in France, and restoration efforts could increase its importance for maintaining salmon in the country significantly. The removal of the two dams would reconnect the 827 km^2 watershed to the sea and transform a 24-km long reservoir back to a steep section of running water.

A long and turbulent process culminated with a final determination in 2017 by the French Ministry of the Environment to remove the two dams on the Sélune. Despite national goals to increase the contributions from renewable energy sources, a decrease in hydroelectric production due to aging infrastructure and the need to comply with the European Union Water Framework Directive called the continued existence of the dams into question (Forget et al. 2018). The federal authorities announced the plans in 2009 following an initiative to make long-term plans for improving biodiversity protection in France (*Grenelle de l'Environnement*). Prior to the initiative the environmental assessments conducted as part of safety inspections at the dams revealed substantial problems with sediment accumulation and harmful algae blooms (Germaine and Lespez 2017). The environmental problems and issues with the aging infrastructure caused the relicensing application to be declined, and the stricter environmental regulations that developed simultaneously prompted the decision to remove the dams.

An interesting aspect of the Selune River decision was the local opposition to the removal of the dams. The reservoirs were considered a positive element in the landscape and attracted tourists and locals alike, and the dams were considered part of the cultural heritage by some. A major reason for the polarization of views on the removal issue was the lack of communication about the process, and a lack of opportunities for participation throughout the process (Germaine and Lespez 2017). Locals felt their voices and inputs were not heard, and that local values were not given a fair weight in the assessment (Germaine and Lespez 2017). Perhaps the most intriguing part of their analysis is the detailed mapping of power relationships and roles of social movements in such complex processes. This helps navigate the strength of causal relationships and brings a more nuanced approach to describing factions that often are painted rather black-and-white and confrontational.

What was gained?
Taking a step back it is clear that hydropower dams and other impoundments are the rule rather than the exception in Atlantic salmon rivers. In many cases dams are the primary reason that populations are in decline or have disappeared. At the same time, hydroelectric power represents a renewable source of energy and an important measure to curb carbon emissions, which

through global warming could represent an even greater threat to salmon and coolwater biota. The question then becomes which rivers to prioritize for restoration and protection against future development.

The decision to remove a dam involves many complex trade-offs and legal challenges. The benefits of dam removal for hazard reduction and ecological restoration are potentially offset by the loss of hydroelectricity production, water supply, and other important services (Roy et al. 2018). Roy et al. (2018) found that increasing the scale of decision making improves the efficiency of trade-offs among ecosystem services, river safety, and economic costs resulting from dam removal. This could simply be because we have more options to draw from when we increase the spatial scale, as demonstrated by the Penobscot case. However, Roy et al. warn that this may lead to heterogeneous and less equitable local-scale outcomes. This, too, is no surprise as some areas will bear the burden, regardless of what that burden might be (loss of hydropower revenue or loss of economic activity and social benefits pertaining to salmon angling).

It is clear that for society as whole, restoration should happen where the ecological gains are the highest, the economic costs are the least, and where the loss of power generation capabilities are acceptable. In some cases it is easy to identify candidate rivers, but in most instances there is no obvious optimum that minimizes conflict between the three aspects. Here, valuation becomes increasingly important but also contentious. Gowan et al. (2006) analysed the decision to breach two dams on the Elwha River in Washington, United States. They found that ecosystem valuation played a minor role in the decision to remove the dams. Furthermore, participants in hydropower relicensing decisions in general do not rely on valuation studies to decide levels of ecosystem enhancements (Gowan et al. 2006). Gowan et al. noted that "*Valuing ecosystem services is inherently a social valuation process and there is very little evidence that public policy participants require monetization of nature's services to make tradeoffs and choices in either precedent-setting or ordinary hydropower-relicensing cases*". This could work in favour of barrier removal in the "obvious" cases but make it more challenging in cases where the aspects come at odds with each other.

The physical changes following dam removal are staggering, and based on dam removals thus far, some general conclusions have emerged. Foley et al. (2017) identified the following patterns from their recent review: *"(1) physical responses are typically fast, with the rate of sediment erosion largely dependent on sediment characteristics and dam-removal strategy; (2) ecological responses to dam removal differ among the affected upstream, downstream, and reservoir reaches; (3) dam removal tends to quickly re-establish connectivity, restoring the movement of material and organisms between upstream and downstream river reaches; (4) geographic context, river history, and land use significantly influence river restoration trajectories and recovery potential because they control broader physical and ecological processes and conditions; and (5) quantitative modeling capability is improving, particularly for physical and broad-scale ecological effects, and gives managers information needed to understand and predict long-term effects of dam removal on riverine ecosystems*" (Foley et al. 2017).

When restoring habitat, will the fish respond? Fewer than 1 % of all fish species (approximately 250 out of some 32,000 species) are diadromous (McDowall 1997). While these migratory patterns between freshwater and the sea are uncommon among fishes, they are critical in understanding how reconnection of freshwater and marine environments through the removal of blockages to migration can lead to re-colonization of fish populations (Pess et al. 2016). In this respect, colonization patterns are important to consider as they can vary between species. Colonization is hypothesized to depend on 1) whether the habitat is accessible; 2) whether the species has the capacity to reach and use the habitat in the context of its life history; and 3) whether the species' patterns of juvenile learning (e.g., olfactory imprinting), attraction to odours of conspecifics, or other mechanistic aspects of migration inhibit or encourage colonization of new habitat (Pess et al. 2014). Pacific salmon and steelhead have relatively high rates of straying - and hence high potential for colonizing new habitat - whereas Atlantic salmon exhibits stronger philopatry and tend to stray less (Pess et al. 2014). In terms of recovery of Atlantic salmon populations in restored rivers it is thus important to allow for a sufficiently long time span to assess the biological effects of the dam removal.

Conclusions

Dam removal as a measure to restore Atlantic salmon represents a relatively new approach to conserving the species and maintain a fishery and the cultural identity that goes along with salmon. The paradox in light of climate change and the need for renewable energy sources is that many - if not most - dams that affect salmon are built for hydropower. By prioritizing barrier removal on larger spatial scales (i.e. not on a case-by-case basis) we can achieve the best ecological outcomes – and the greatest gains in ecosystem services - for the lowest cost and the least loss of power production. In addition, the return of salmon permits the continued connection between people and salmon, hence restoring relationships that have been lost or degraded. Restoring the social and cultural capital associated with salmon has great value but may be more difficult to valuate than the direct losses in revenue or the direct cost of decommissioning. However, the social and cultural importance of salmon need to be taken into account in the decision processes, and care must be taken to document the historical value of salmon in affected rivers.

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5.3.2 Habitat restoration in the Skjern River, Denmark

Country: Denmark, North Sea Coast

Purpose: Examine the failed attempt to straighten and channel a river from its floodplain and the economic costs of restoring the river and native Atlantic salmon.

Introduction
The Skjern River is coined the most important river for Atlantic salmon in Denmark. As the most voluminous of rivers in the country, it is also a local hotspot for biological diversity due to the large wetlands that form near its estuary on the North Sea Coast. The lower section of the Skjern is the scene for the largest river restoration project in Northern Europe. The restoration happened in response to a series of environmental and economic problems that resulted from channelizing the main stem and draining its floodplain in the late 1960s. Although the road to recovery is long, preliminary results suggest "that it is going in the right direction". This case study describes the setting of the river, the history of impacts, and the restoration efforts that have taken place.

What was measured?
We analyse the economic costs of restoring the hydrological and ecological connection between a river and its valley. We use both empirical data from after the restoration was completed and economic forecasts written before the work took place.

History, impacts, and unintended problems
The Skjern River is the largest river in Denmark, draining 2490 km^2 of sandy plains in western Jutland with a mean annual discharge of approximately 35 $m^3 s^{-1}$ and peak discharges of 200 $m^3 s^{-1}$. The river discharges into Ringkøbing Fjord on the North Sea coast, which is a large, shallow, and brackish lagoon. The landscape is very flat with a vertical relief of only 70 m from source to estuary, and consequently the river meanders vigorously along its 94 km course (Figure 5.6).

Due to the low topographical relief, a relatively high sediment load and a shallow estuary, the lower portions of the watershed were prone to flooding. Historical maps from the 18th century suggest that the lower 10 km of the river anastomosed (i.e. split into multiple channels) and created islands and a mosaic of wetlands (Kristensen et al. 2014), a typical pattern in low-gradient portions of rivers close to estuaries (Rosgen 1996). The flooding was vital to the plant communities which absorbed excess nutrients and contributed to the settling and binding of fine sediments.

The watershed was – and still is – important for agriculture. Flooding has therefore had undesired economic consequences for local farmers and the agricultural economy in the region. Early records show that farmers have made irrigation canals, drainage ditches and smaller embankments for centuries, but at a relatively small scale. In an attempt to bolster the agricultural economy, the Danish government funded a major land transformation in the late 1960s. The lower 19 km of the river were channelized, lowered, and embanked to prevent flooding, and the surrounding floodplain was diked. By disconnecting the river from its floodplain, and by diking the historical floodplain and pumping water back into the channel, an arable area of 40 km^2 was created.

The draining of the floodplain and the disconnection of the Skjern from its floodplain had a number of unintended consequences. Whereas terrestrial plants and wetlands previously absorbed excess nutrients and bonded fine sediments transported by the river, the nutrients and sediments spilled into the Ringkøbing Fjord after the river was channelized. The water became cloudy from the sediments, and algae thriving on the increasingly available nitrogen and phosphorous caused noxious blooms in summer. The land level of the floodplain also dropped as the top layers dried out, making drainage ineffective and costly. Finally, conversion of biodiverse wetlands to monocultures had deleterious effects on the flora and fauna; however, the effects have not been quantified.

These negative outcomes, in conjunction with changing economic outcomes for the crops and degrading quality of the newly created farmland, made it clear that the project was an economic and environmental failure. In 1987 the Danish government began forming plans to restore the river and the floodplain, which were formalized in an act passed in 1998 (Law no. 493 / 03 July 1998 "Forslag til Lov om Skjern Å Naturprojekt"). The objectives were many, but the fundamental goal was to recreate a functional river ecosystem through the structural reversion of past impacts.

The restoration process and early results with regards to salmon
Describing the effects of a restoration project of this scale is beyond the scope of this case study, and we refer the reader to Andersen et al. (2005) who provide a nice summary of the project and the changes following the completion of the restoration. In short, the restoration work was carried out from 2000 to 2002 and included the reversion of the lower 19 km channelized section back to a 26 km meandering river channel; reopening of 40 km side channels and tributaries; and the formation of a 5 km^2 lake (Hestholm) and 13 km^2 of wetland and playa (intermittent lake that forms after floods). The nutrient retention has not improved significantly following the restoration project, but the sediment retention has increased by an estimated 5 to 10 %.

Figure 5.6. The Skjern River by Lønborg. Photo by Morten Kristensen / Creative commons https://commons.wikimedia.org/w/index.php?curid=3443901

With regards to Atlantic salmon, the trend in returning adults is increasing. It is hard to discern the effect of the restoration because of hatchery releases and changes in commercial fisheries in the Ringkøbing Fjord. From 1996, approximately 74 000 juveniles have been released annually (Pedersen et al. 2007b), and recent figures suggest annual releases upwards of 150 000 juveniles. This led to an increase in returning adults from 1984 to 2004 from less than 50 individuals to over 800 (Koed et al. 2006, Pedersen et al. 2007b). The restoration of the river channel started in 2000, so the increase in returning adults over that time period was not a result of the restoration work. The number of returning adults in 2018 is unknown, however, anglers caught 1748 fish, of which 76 % were released. In sum, the combination of hatchery supplementation, changes in saltwater fisheries, proliferation of catch-and-release river fisheries, and improved habitat has led to a substantial increase in the number of Atlantic salmon in the Skjern River.

At the same time as the Hestholm lake formed, cormorants (*Phalacrocorax carbo sinensis*) that nested in the lagoon started using the river to a larger extent than prior to restoration, presumably because they used the lake as a resting area between feeding bouts (Koed et al. 2006). Avian predation in-river was not observed in year 2000, but was documented for the first time in 2002. This suggests that cormorants opportunistically began resting in the Hestholm lake as it was forming and shifted their foraging habits (Koed et al. 2006). This is likely a combination of behavioural adjustments to better resting habitat, a functional response to higher numbers of smolts from hatchery releases, and an overall increase in cormorant populations in Europe over the last decades (Bregnballe and Sterup 2018, Frederiksen et al. 2018).

Identification and analysis of values

The Skjern River restoration project is the largest river restoration project in Northern Europe, both in terms of area and direct costs. A total of 22 km^2 of floodplains, wetlands, and river channels were restored. Total costs amounted to 37.7 million EUR (adjusted for inflation, this amounts to 43.6 million EUR in February 2019), of which land procurement was approximately 30 % (Table 5.3). These figures only the direct expenditures associated with the restoration work and must be viewed as a minimum sum. They do not include the long-term ecological and hydrological monitoring costs, costs associated with unforeseen events, repairs or maintenance of structures, or costs associated with hatchery supplementation.

Table 5.3 – Total costs of the Skjern River restoration project (in millions of euros, from Pedersen et al. 2007).

Item	Cost (M €)
Land procurement	12.6
Project planning	2.6
Construction works	16.1
Public recreation facilities	2.8
Environmental monitoring	2.3
Other costs	1.2
Total	37.7

We were unable to find any recent studies on the long-term economic impacts of the project. However, Dubgaard et al. (2002) performed a cost-benefit analysis of the restoration project as the work was still in progress, and this is probably the most comprehensive analysis available. The following costs were included in the analysis: project costs, operation and maintenance, forgone land rent, and closing of a fish farm. Of potential benefits, the following factors were considered: termination of emissions from fish farm, saved pumping costs, better land allocation, reed production, reduced flood risk, reduction of nitrogen, reduction of phosphorus, reduction of ochre, better hunting opportunities, better angling opportunities, better outdoor recreation, and biodiversity (existence value). Only this study valued non-market environmental benefits and the loss of revenue from loss of land rent.

It is difficult to partition the value of salmon from the value of the river, but Dubgaard et al. used estimates derived by Toivonen et al. (2000) to extract the value of angling. Toivonen et al. (2000) estimated that Danish anglers' consumer surplus average was 616 DKK/angler/year (measured as the hypothetical willingness to pay for access to angling minus the expenses associated with angling). For the Skjern River, the relevant benefit is the value of the expected improvement of the angling opportunities. Although such an analysis was not available in Toivonen et al. (2000) a similar scenario was valued based on the following scenario:

"Imagine that there were a River near your home which for many years had been closed for recreational fishing… The River has a natural stock of salmon and sea trout, which allows for an

above average chance of catching these fish species. Imagine that the River is opened to recreational fishing with rod and line… To get access you will have to pay a rent that would grant you 12-month right to fish in the River… What is the most you would be willing to pay….?" (Toivonen et al. 2000).

Toivonen et al. (2000) found the that the willingness to pay was in the interval between 550-921 DKK per year per angler. It is not a perfect proxy because it was possible to catch salmon in the Skjern River before the restoration (hence not a zero-opportunity baseline), and it should be interpreted as an overestimate in relation to the Skjern situation.

At a 3% discount rate and a time horizon of 20 years the present value of net benefits amounted to approximately 30 million DKK (adjusted for inflation this equals 38.4M DKK / 5.15M EUR in 2019). At 5% the present value of net benefits came close to zero. At 7% the benefits could no longer cover the costs (Dubgaard et al. 2002). When assuming an indefinite time horizon, however, the economic outcome of the project improves substantially. At a discount rate of 3%, Dubgaard et al. (2002) found the 2002-value of net benefits amounting to 225 million DKK (288.3M DKK / 38.6M EUR in 2019). At a 7% discount rate (the level recommended by the Ministry of Finance) the project provides a present value of 8 million DKK (10.25M DKK / 1.37M EUR in 2019).

Empirical assessments in the years following restoration are largely lacking, both at a national scale and a local scale. The economic impacts of the restoration on the local economy have not been adequately assessed due to lack of data before and after the project (Wiberg-Larsen & Koed 2013). However, Wiberg-Larsen & Koed (2013) estimated that angler expenditures annually contributed 7.7 M DKK / 1.03 M EUR (adjusted for inflation this corresponds to 7.97M DKK / 1.07M EUR in February 2019) to the local economy based on 34,000 fishing days. Additionally, other sectors of the outdoor industry (birding, hiking, wildlife viewing etc.) contribute approximately half of what the angling industry generates, leading to an estimated annual influx of 12M DKK / 1.6M EUR (12.4M DKK / 1.66M EUR in 2019) to the local economy from the outdoor industry in the Skjern River valley. The Wiberg-Larsen & Koed (2013) study was not a cost-benefit analysis and did not consider the long-term costs of the restoration on the local economy. The figures presented in their analysis were therefore overestimates of the net benefit of the restoration, but the different methods used prevent a direct comparison with the Dubgaard et al. (2002) study. The authors note, however, that the revenue from angling was much higher than forecasted by the Dubgaard et al. (2002) study because the salmon population increased faster than expected.

Qualitatively, we can assume that much of the revenue from the outdoor industry is a direct result of the restoration of the lower Skjern. Salmon angling is perhaps the most direct outcome, as increased returns create a larger and more lucrative fishery. However, separating the effect of hatchery supplementation from the changes that occurred to the river's capacity as spawning and rearing habitat for wild salmon following restoration, is impossible. For other sectors of the outdoor industry, such as birding, there were direct positive effects of the restoration (Wiberg-Larsen & Koed 2013). Improved habitat quality (wetlands and lakes) significantly increased the abundance and diversity of birds, making the 22km^2 complex an area of national importance to biodiversity (Andersen et al. 2005, Pedersen et al. 2007b). Access was improved by the land procurement and the establishment of bird towers and hiking paths.

Conclusions

The Skjern River restoration project represents a large-scale attempt to restore habitat and ecosystem services that were lost not too long ago. It also shows that restoring the river to pre-intervention conditions is unattainable on the short term. An interesting aspect of the channelization and the subsequent restoration is the ephemeral nature of what constitutes a "profitable decision for society". The poor economic outcomes from a changing demand in the external market showed that in a matter of a decade, the intervention was based on the wrong outlook of consumer demands and cost of producing the products. This highlights how external markets can change the profitability of "taming the river" on relatively short time steps. Restoring the Skjern River represents net gains for society in terms of ecosystem services, driven by increases in salmon returns, the re-establishment and creation of biodiverse wetlands, and slightly improved nutrient and sediment retention which improves water quality in the Ringköbing Fjord.

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5.3.3 Economic activity associated with restored salmon stocks in the River Tyne

Country: England (UK)

Purpose: To illustrate the economic activity derived from a restored salmon fishery.

Introduction
Mawle & Milner (2003) describe the return of salmon to many rivers across England and Wales following reductions in pollution, of which the Tyne is the outstanding example. Historically, the Tyne was the ‘first salmon river in England’ but during the twentieth century, the estuary became grossly polluted by industrial discharges and domestic sewage. The rod catch fell to zero in the 1950s. Due mainly to a clean-up of the estuary, accelerated by stocking (Milner et al, 2004), together with in-river improvements and reductions in exploitation, the annual rod catch has, since 2004, usually exceeded three thousand salmon as shown in Figure 5.7. Almost 80 percent of the catch is now released (Environment Agency, 2018). The stock also contributed to the commercial North East Coast Salmon Fishery which, as a mixed stock fishery, was being phased out. The Tyne is once again the most productive salmon river in England.

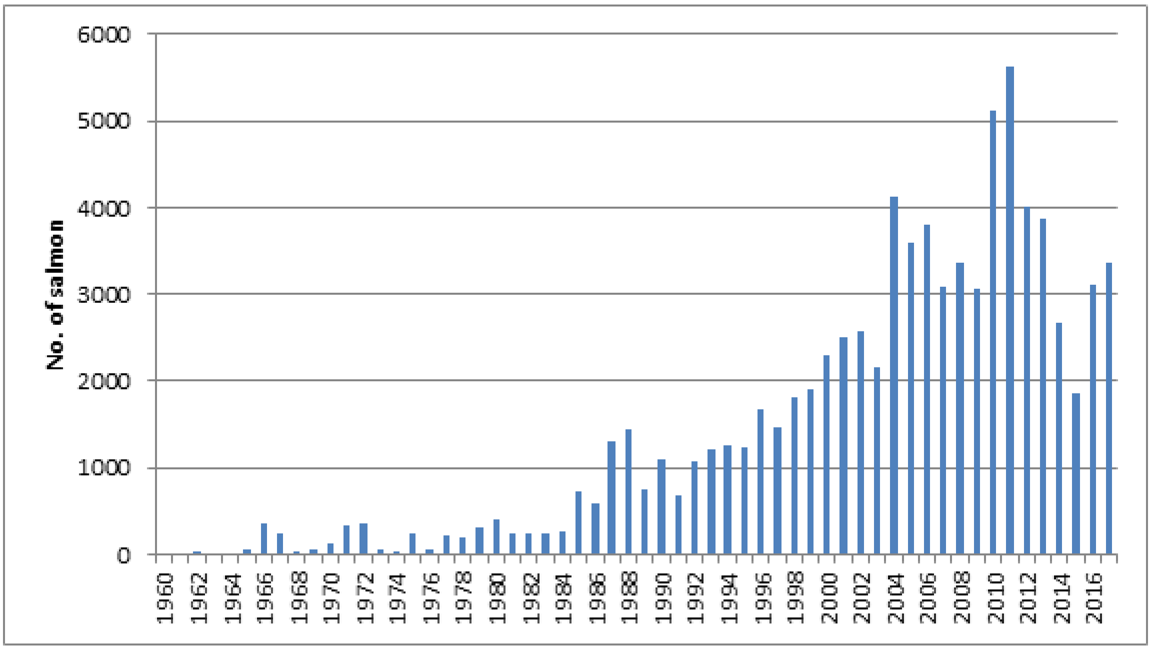

Figure 5.7. The declared rod catch for the River Tyne, England (UK) from 1960 to 2017, redrawn from Mawle & Milner (2003), extended by data from Environment Agency (2013; 2018a).

What was measured?
In 2012, when revising fishing regulations for the North East Coast Salmon Fishery, the Environment Agency (2012a) reviewed and estimated the economic activity associated with the rod and net fisheries based on data from catch returns from fishermen, economic data from previous studies (Radford et al, 2007), and consultation responses. A questionnaire survey of netsmen provided data on the first sale value of their catch. A subsequent review for the Environment Agency in 2016 included a further evaluation of the net catch (Amec Foster Wheeler, 2018).

Based on genetic studies, the Environment Agency (2012b) estimated that 45 percent of the net catch of salmon in the coastal fishery was destined for English rivers, including the Tyne. If the Tyne’s contribution was in proportion to the rod catch given by Environment Agency (2013; 2018a), then two-thirds of the net catch of English salmon would have been derived from the Tyne, equivalent to 30 percent of the total net catch.

Economic activity associated with the rod fishery
Catch returns from anglers recorded just over 23,000 days fished for salmon and sea trout on the Tyne in 2011, though this was a minimum as some anglers fail to submit effort data (Environment Agency, 2013). Expenditure per day was given in Environment Agency (2012a) as £86 (adjusted to 2018 prices) indicating expenditure associated with angling of around £2 million within the region for the year. Expenditure associated with salmon and sea trout angling across the north east regions of England had previously been estimated in a national survey (Radford et al, 2007; Mawle & Peirson, 2009) to support, directly and indirectly, the equivalent of 192 full-time jobs (FTEs). Just over half, 53 percent, of the rod days fished in these regions for migratory salmonids in 2011 were on the Tyne, indicating that salmon and sea trout angling on the river supported about 100 FTEs.

Economic activity associated with the net fishery
Environment Agency (2012a) records that there were 189 individuals, including licensees and endorsees, directly employed in the net fishery, comprising fixed coastal nets and drift nets from locally traditional boats, as shown in Figure 5.8. The salmon fishing season is only three months in the summer. Though its relevance was noted, no estimate was made of the total contribution of the fishery to employment in ancillary businesses. Nonetheless, there could be substantial value added to the catch as it was sold on between fish merchants, including abroad generating export earnings, as well to local hotels, restaurants and the general public. For example, a 100g portion of wild salmon sold in a meal at a restaurant or hotel could sell for about 29 £ / 35 €, equivalent to about 290 £ or 348 € per kg.

Figure 5.8. A traditional Northumbrian coble setting a drift net for salmon off the North East coast of England, UK.

The first sale value of the net catch of salmon and sea trout was estimated to be 1.4 M £ / 1.68 M € (adjusted to 2018 prices), three-quarters of which was derived from salmon, i.e. about 1 M £ / 1.2 M €. Amec Foster Wheeler (2018), using the same data for first sale price, estimate that the value of the salmon catch in the North East Coast Fishery in 2016 was somewhere between 500 000 £ and 1 M £ (0.6-1.2 M €). They estimated the average seasonal income from salmon per licensee, for 59 licensees, to be between 8000 and 16 000 £ (9600 – 19 200 €). However, some individuals would have earned considerably more. The Environment Agency (2018b) notes that the fishery was 'economically viable' and had a 'high economic value' in 2016 and that one individual licensee had gross income of 80 000 £ / 96 000 €, derived mainly from salmon.

As indicated above, about 30 percent of the salmon catch would have been derived from Tyne salmon, so that the river contributed up to 300 000 £ / 360 000 € in gross income to coastal fishermen.

Conclusion
In addition to the ecological benefits, the restored salmon stock in the River Tyne provides significant employment in the north east of England through expenditure by salmon anglers. It has also contributed to improved incomes of coastal net fishermen through a seasonal fishery.

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5.3.4 The economic impacts of *Gyrodactylus salaris* infections and of restoration interventions in Norwegian rivers

Country: Norway

Purpose: Highlight the economic value of salmon angling, the economic impacts of *Gyrodactylus salaris*, and the economics of intervention to eradicate the parasite.

Introduction
The monogenean ectoparasite *Gyrodactylus salaris*, commonly known as salmon fluke and hereafter named gyro, is endemic to the Baltic Sea and was accidently introduced with a

shipment of Baltic salmon fingerlings to a research hatchery in Sunndalsøra, Norway. The hatchery delivered salmon fingerlings for stocking purposes to several Norwegian rivers, and gyro was discovered for the first time in a Norwegian river (Lakseelva in Misvær municipality) in 1975 (Norwegian Directorate for Nature Management 2008). Since then, 50 rivers have been infected by gyro (Figure 5.9). The first attempts to eradicate the parasite with chemical treatments began in the 1980s, with variable success. During the last 10-15 years, as knowledge and methods have improved, chemical treatments are becoming more successful. By 2019, 32 rivers have been treated successfully and 11 rivers are under a 5-year monitoring program to determine the outcome of treatments. In 2019, 6 of these rivers are expected to be declared successfully treated. By March 2019, gyro occurs only in 7 Norwegian rivers (Figure 5.9).

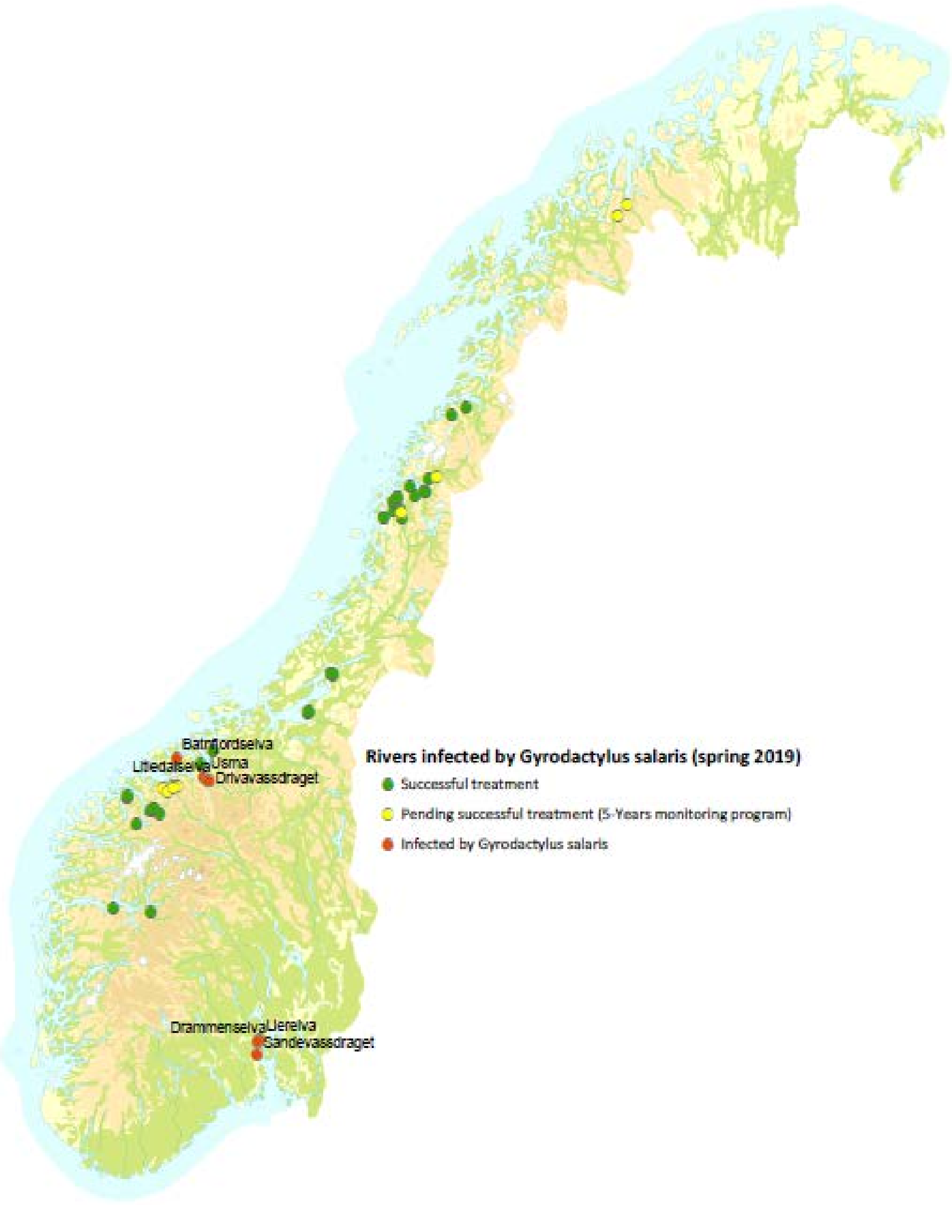

Figure 5.9. Salmon rivers infected by gyro in Norway. Green dots = successful treatment, yellow dots = pending review, and red dots = currently infected by gyro.

Gyro kills almost every salmon smolt in infected rivers. Increased mortality of salmon smolt reduces competition with sympatric sea trout (*Salmo trutta*) and/or sea run char (*Salvelinus alpinus*). Reduced competition in turn may lead to increases in population sizes for those species. For anglers, this partly compensates for lack of salmon in infected rivers. Several of the historically best rivers for salmon angling in Norway have been (Vefsna and Lærdal) - or still are (Rauma and Driva), infected by gyro.

A massive eradication program for gyro has been conducted over decades (Norwegian Environment Agency 2014, see also Figures 5.9 and 5.10). The eradication program has two important aspects: (1) costs related to the eradication treatment of the river and re-establish local salmon population, and (2) the benefits related to local economy from value creation from salmon angling. Since 1982, the Norwegian Environmental Agency has spent more than 74.7 M € related to gyro (Norwegian Environment Agency 2014), and it is estimated that gyro causes economic losses around 30,7 M € annually (Norwegian Environment Agency 2014).

What was measured?

<u>Direct economic value</u>
During the last decade, there have been two estimates of the direct economic value (DEV) of salmon angling in Norway. In 2010, the estimated DEV was 141.4 M € (Norwegian Forest Owner's Federation 2010), with a predicted potential to reach 244.2 M € in year 2020. However, the 2020 prediction seems quite optimistic, given the fact that number of salmon anglers is decreasing. The most recent DEV estimate was conducted by Andersen and Dervo (2019), who estimated anglers' daily expenses and DEV related to salmon angling in Norway. The average daily expenses for salmon angling was an estimated 187.6 € per angler. The estimated DEV related to salmon angling was 129 M €. Value creation to local economy was estimated at 46.4 M €, while value creation including rippling effects was estimated at 62.6 M €.

The estimates were based on data from the Norwegian salmon angling fee registry, in addition to former national surveys of hunting and angling participation, describing their effort and leisure activity. Data on expenditures are retrieved by a specific survey among salmon anglers (clients and customers) to the iNatur website.

In a 10-years perspective (to year 2028), Andersen and Dervo (2019) estimated DEV from salmon angling within the interval m€129-167.2, which seems more realistic than the former 2020 prediction. Estimated direct value creation and value creation including rippling effects was estimated to be 46.4-60.2 and 62.6-81.3 M €, respectively.

<u>Local economic impact</u>
Andersen et al. (2019) estimated how gyro affects the local economy and value creation from recreational salmon angling in three important salmon rivers (Lærdal River, Driva and Vefsna) which are, or have recently been, infected by gyro. The local economic impacts (LEI) were calculated, in addition to value creation (VC) and rippling effects (VC multiplied by a factor of 1.35) from recreational salmon angling.

What was gained?
Gyro was detected for the first time in the Lærdal River in 1996 (Figure 5.10). The river was treated with rotenone in 1997. Gyro was rediscovered in 1999 and the next treatments (with aluminium and rotenone) were after the 2005 and 2006 seasons. In 2007, gyro was once again discovered in Lærdal River. The third treatment was after the 2011 and 2012 seasons (with aluminium and rotenone). After 5 years of monitoring, the treatment was declared successful in 2017. LEI and VC from recreational salmon angling in Lærdal river before infection were estimated to be 2.0 M € and 1.26 M €, respectively. During infection (1997-2011), LEI and VC dropped to 1.55 and 0.70 M €. After treatment (2012) LEI and VC increased to 16.4 and 10.3 M € respectively.

The estimated capitalized value of salmon angling in Lærdal river was 35.6 and 42.5 M € before and after the infection, and 23.5 M € during infection. This equals a value loss of 12.1 M € (before infection- during infection) and 19.0 M € (during infection-after infection). However, the value loss is much higher than the accumulated cost of the gyro- treatment (4.6 M €). The cost-benefit factor of the gyro-treatment was 2.6 times the cost in Lærdal river.

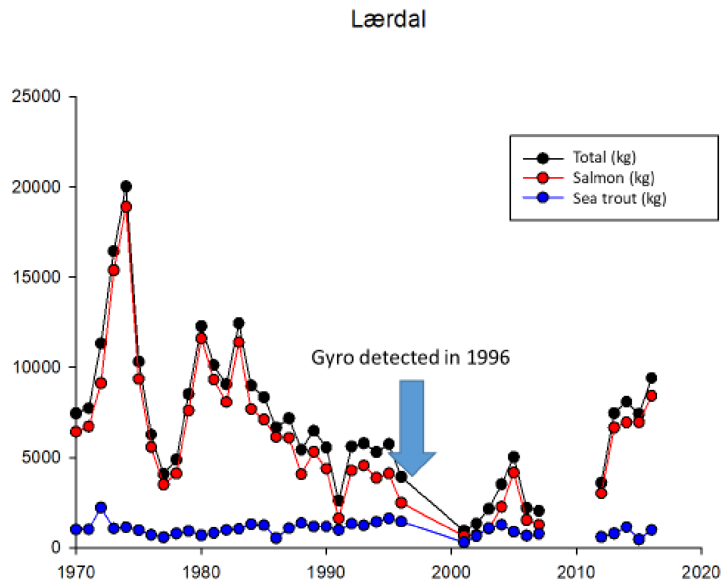

Figure 5.10. Total annual reported catches in Lærdal river (kg) for salmon and sea trout, 1970-2016.

In Driva, gyro was detected in 1980 (Figure 5.11). The river has not been treated with rotenone yet, but a migration barrier was constructed 25 km upstream from the mouth and implemented in 2017. No fish can migrate upstream the barrier, and fishing are not allowed upstream the barrier. Construction cost were 7.,16 M €, and it is estimated that treatment with rotenone and aluminium will cost 1 M €. The main idea with the migration barrier is to reduce the area to treat with rotenone and aluminium. Estimated LEI and VC before infection were estimated at 3.93 and 1.32 M €. Under infection (the current situation) expenses and value creation were estimated to be 1.78 and 0.59 M € without rippling effects. Andersen et al. 2019 estimated that the fish migration barrier (constructed in 2017) reduces the total angling effort in the river by 25%. The value creation downstream the migration barrier was estimated at 0.30-0.45 M €. The estimated capitalized value before infection was 44.8 M €, compared to 20.2 M € during infection, which equals a value loss of 24.7 M €. The capitalized value of angling downstream the migration barrier was estimated at 10.1-15.0 M €, depending on the angling effort in the calculation. The cost-benefit factor of eradicating gyro from Driva was estimated to 3.

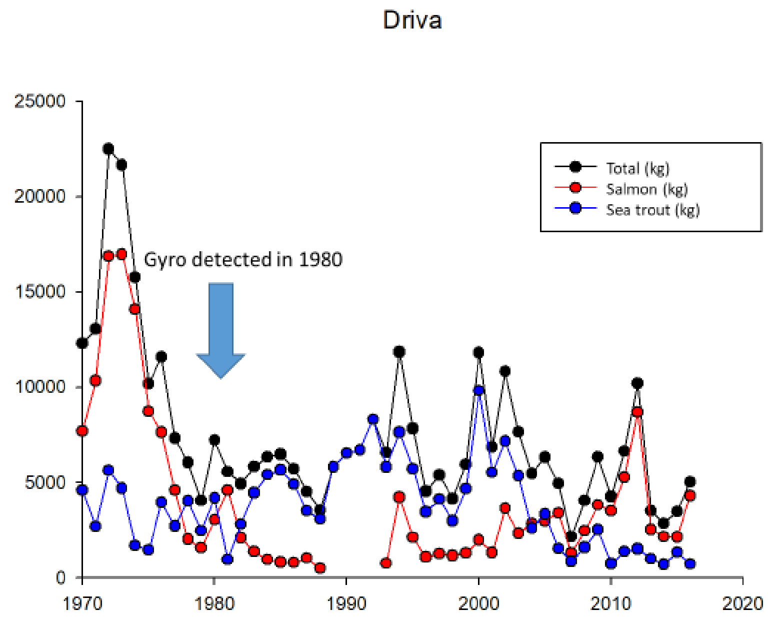

Figure 5.11. Total annual reported catches in Driva river (kg) for salmon and sea trout, 1970-2016.

Gyro was detected in Vefsna in 1978 (Figure 5.12). Before Vefsna was infected by gyro, it was among the top-ten rivers in Norway regarding total annual catches. From late 1990s to 2010 the sea trout catches were extraordinarily good (Figure 5.12). The river has been closed for angling since 2010 and the eradication programme for the catchment was finished in 2012. Recreational angling (after successful treatment) in Vefsna reopened in 2018, with a limited season and reduced number of anglers. Based on data from the 2018 season, we estimated 17 000 angling days on "full capacity" regarding season length and angling all over the anadromous part of the river system. LEI and VC were estimated at 2.56 M € and 0.97 M €, respectively.

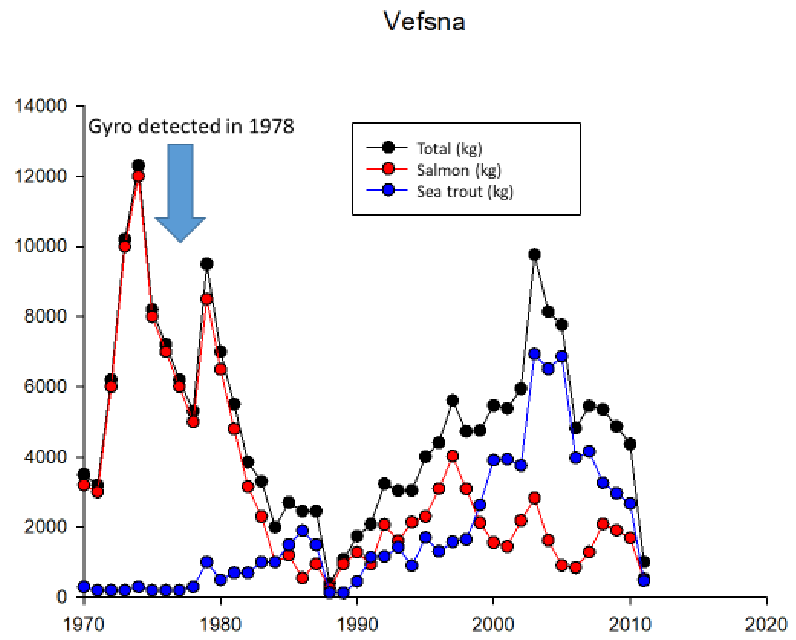

Figure 5.12. Total annual reported catches in Vefsna river (kg) for salmon and sea trout, 1970-2010.

Compared to other, similar rivers, we believe the capacity can reach 25 000- 35 000 angling days, which equals LEI between 4.1 and 5.3 M €. In river Vefsna, the present capitalized value was estimated to be 33.3 M € in the current situation. For the scenarios of 25- 35 000 angling days, the capitalized value was estimated to 48.6 and 68.1 M €, respectively.

Conclusion

Table 5.4 sums up the estimates of local economic impact (LEI), value creation (VC) and value creation including rippling effects in the rivers Lærdal, Driva and Vefsna in Norway. We can safely conclude that eradication of gyro and re-establishment of wild salmon populations are highly profitable in an economic perspective for local communities including associated business activities and jobs. Assuming that there are additional values, especially related to non-use values (conservation values) and net use values for fishers, these restoration efforts are highly profitable, for local communities as well as for society in general. Furthermore, they highlight that by eradicating the parasite we can relatively quickly recover local economies and prevent a long-term interruption of people's connection to salmon.

Table 5.4. Estimates of local economic impact (LEI), value creation (VC) and value creation incl. rippling effects for Lærdal before, during and after infection, Driva before and during infection with 5 (5D) and 10 days (10D) angling effort from non-local anglers and downstream migration barrier. For Vefsna numbers describe scenarios with varying angling effort; 17000 angling days (17K), 25 000 angling days (25 K) and 35 000 angling days (35 K).

Period or scenario	**LEI m€**	**VC m€**	**VC incl. rippling effects m€**
Lærdal before infection	2.00	1.26	1.70
Lærdal during infection	1.55	0.70	0.94
Lærdal after infection	1.68	1.05	1.42
Driva before infection	3.93	1.32	1.79
Driva 5 days and 10 days	1.18-1.78	0.40-0.59	0.54-.81
Driva, downstream barrier, (5 days and 10 days)	0.88-1.33	0.30-0.45	0.41-0.60
Vefsna 17 000	2.57	0.97	1.32
Vefsna 25 000	4.09	1.43	1.94
Vefsna 35 000	5.30	2.02	2.71

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6 Discussion and conclusions

Wild Atlantic salmon provide humans with a range of values, benefits and gifts (collectively referred to as ecosystem services). Several scientific disciplines are needed to provide a sufficiently broad, nuanced and relevant description of these services. As became clear from this report, it is difficult to find a common unit to describe the range of values. Even though valuation studies are becoming increasingly sophisticated and include a broader set of variables, it is inherently difficult and contentious to put economic figures on phenomena and activities that evoke emotional attachment and cultural connections across several stakeholder groups. In addition, these connections are dynamic. Even purely economic-oriented studies are subject to substantial uncertainty in their estimates of aspects pertaining to costs and benefits. Nevertheless, the goal of this report was to highlight the various values attached to wild salmon and the uncertainties associated with this endeavor, and give an overview of relevant research on the social and economic values of wild Atlantic salmon published in peer-refereed journals and national "white-paper" reports or assessments since 2009, when the compilation of the socio-economic subgroup of NASCO ended its work (NASCO, 2010).

A literature review identified 41 studies of the different values of wild Atlantic salmon published between 2009 and 2019, dominated by economic studies. Few studies of the cultural values were identified. While the topic of cultural values remains an active field of research in the range of Pacific salmonids, there seems to be fewer studies that directly concern the cultural importance of wild Atlantic salmon. Studies on the cultural values and the local knowledge of salmon represents an important progress towards acknowledging a wider range of values.

Single (river- or regional) studies on catch, effort, and spending are more precise and accurate than national statistics because their scopes are smaller. Scaling up to national levels and range-wide, it is difficult to maintain this level of precision and accuracy. There is hence substantial uncertainty in the data on catch, effort, and expenditures at national and international levels. This becomes a problem when we try to assess the total value of wild Atlantic salmon. The numbers presented here are likely underestimates of the true value of salmon, because 1) data are lacking from portions of the range, 2) methods are insufficient at valuing a diverse range of ecosystem services, and 3) many social and cultural values are impossible to capture with economic figures. The latter two points are subject to research and development in the scientific literature, but they are tightly connected to point number 1: to comprehensively estimate the total value of salmon we need to know how many fish are caught and how much effort went into it. Moving forward, improved reporting by NASCO parties would provide a far better basis to estimate use values, especially of number of fishers (primarily recreational/rod, and net/trap), their effort, and associated average expenditures. Importantly, this would *improve our ability to monitor changes in values that most likely currently are changing at a significant pace*.

Salmon are naturally valued by fishers, but also other people value wild salmon, and for several non-consumptive reasons. These values are termed as use- and non-use values (Figure 5.1) and are included in the concept of Total Economic Value (TEV). The TEV of wild Atlantic Salmon can be estimated for the general public over and above its consumptive and non-consumptive values related to fishing, which has been done in some countries. Giving a precise estimate of the total economic value of Atlantic salmon tends more towards a theoretical exercise, since the view of value, as already mentioned, differs between people and cultures. For many households the value of Atlantic salmon is usually small but cumulatively across a larger population it can be large. Also, the value people put on wild Atlantic salmon can be increased by public education. In so doing, raising awareness of the wild Atlantic salmon and the factors affecting the future of stocks is imperative to pass on healthy ecosystems to future generations. Higher values may be placed on protecting healthy stocks than from improving poor stocks. Studies are showing that willingness-to-pay for a programme to improve stocks will be greater if it has high likelihood of success.

A number of studies have shown that that restoration of wild Atlantic salmon in rivers where they were formerly functionally extinct can be ecologically successful and highly economically viable. Range-wide and especially for salmon populations at the fringe of the historical distribution, habitat destruction, changes to the flow regime, and introductions of alien species have caused local extirpations and cessation of fisheries. For conservation of the species, these fringe populations are particularly important because they represent adaptations to a greater breadth of conditions than at the core of the range, and for people they also represent important knowledge and non-use values to avoid the extinction of experiencing (Miller 2005) native Atlantic salmon. Attaining a basin-scale perspective can help reach comprehensive solutions whereby the decommissioning of obsolete dams does not necessarily imply an overall reduction in power generation. By removing the dams that provide the least benefit at the greatest cost (both in maintenance and detrimental effects on salmon and stream ecosystems), and increasing production in remaining dams, there can be a substantial net benefit. As shown in the Sélune River case, there can also be resistance to removal among locals because the dammed river has become the new normal (similar to the shifting baselines syndrome (Pauly 1995).

Net and trap fisheries in 2017 were estimated to catch nearly 500 tons, representing approximately 185 000 salmon. Minimum 5400 people fished for Atlantic salmon with nets and traps. Most are considered subsistence fisheries valued for their cultural benefits, and little wild Atlantic salmon fisheries are commercial and it is therefore of little relevance to estimate the overall economic value of the catch. The number of licenced net and trap units has been reduced from over 5000 in 2000 to well under 2000 in 2017. The registered catch was 700 tons in 2007, and while the figures are not directly comparable to the estimate for 2017, it suggests a reduction of 30 %. The catch represents approximately 185 000 salmon. While some countries have had some reductions (e.g. Canada and Norway), others have plummeted or ended, such as Scotland, Northern Ireland and Russia.

The dynamics of the value humans put on wild salmon depend on larger trends in society. The example of the price of commercially caught wild salmon and the price of farmed salmon provides an example of this. Here, the measurement unit is the same (i.e. price per kg), hence avoiding the challenges with valuation of social and cultural values, and the data are recorded in the same manner in the same place over a long time period. In the beginning of the period (1978) the price for both wild and farmed salmon were high, exceeding 20 £/kg. The price for farmed salmon, however, declined rapidly over the next decade, and then steadily over the following 25 years. The price for wild fish followed the downward trend until the mid-1990s, after which it showed an overall, albeit volatile, upward trend. The reason for the divergence in prices since the 1990s could be manifold, but likely reflect greater spending power overall, reduced production costs and increasingly negative publicity of farmed salmon. As the industry grew and more farmed salmon made it to people's dinner table, ecological problems with escaping fish, health concerns over the quality of the product, and environmental concerns over farming practices made headlines. The declining net and trap catch during this period drove the unit price for wild salmon upward, resulting in a relatively stable gross value of wild fish. These changes show that while *salmon as a food source* became more available (both in higher quantity and lower price), the value put on *wild salmon* increased substantially. The shifting priorities reflect the social context of valuation which in large part is the result of availability and market mechanisms.

Due to uncertainties in the data, a precise estimate of angling (rod fishing) activity for salmon in 2017 across the North Atlantic is not achievable. Nonetheless, it seems that there were about 300 000 salmon anglers fishing for approximately 2 000 000 days, to catch about 380 000 salmon in 2017, taking into account likely activity in countries with missing data on angler numbers and angling days for 2017. For those countries with data from both 2007 and 2017, licencing data suggests stability as a major trend, while Norway likely has had a significant reduction. For number of salmon caught, there has been a reduction of approximately -25 000 salmon from 408 000 in 2007 to 384 000 in 2017, which equals a decline of – 6%. Though the rate of catch and release varies highly between countries, all countries report a significant increase in the rate of released fish in angling from 2007-2017. However, inaccurate or missing data from Canada and Russia brings uncertainty to the estimates. In countries with higher-quality effort data the pattern of declining effort is more trustworthy. In sum, there is indication that anglers put less effort in their salmon angling in 2017 compared to 2007, while the catches seem to have been more stable.

Angler expenditure varied substantially, both between and within countries. From the national studies, estimates varied from €100 per day in England and Wales (UK) to over €600 per day in Iceland. As expected, there is also substantial variation in angler expenditure within countries. This probably reflects differences in spending power and attractiveness of rivers. For example, daily spending ranged from €122 to 267 per angler in Norway on a selected number of rivers, excluding both some of the cheaper and most expensive. From river-based surveys, there is reason to assume that the average daily expenditure per angler is within the interval of 150-250 €/day for most portions of the Atlantic salmon range. Given the effort are within the range of 2 000 000 angling days and the daily expenditure in the range of €150 -250 per day we get an estimated 300-500 m€ in overall expenditures from salmon angling in the NASCO area.

Among the changes we have observed over the last decade, the rising prevalence of catch-and-release angling is particularly clear. From being a management method to minimize take in areas where anglers could not be excluded due to rights of access (United States and Canada), it has now become widespread across Europe with largely private fishing rights. Both stricter regulations and changing norms among anglers contribute to this rapid change (Stensland et al., 2013). The increasing prevalence of C&R angling suggests changing values in society. Even though C&R was already prevalent during the previous social and economic report (NASCO 2010), the trend has solidified and spread to new regions and rivers. The trend can be explained by recruitment of young anglers that have other sources of information, aided by the internet and a more generalised set of norms among anglers promoting voluntary release (Stensland et al. 2013). Furthermore, many river associations (Europe) encourage C&R and set low bag limits, which selects for anglers that accept the regulations. As seen in the Harry's River case study, this can exclude harvest-oriented anglers and have unwanted distributive effects considered unfair by relevant stakeholders and angler groups.

Maintaining people's connection with salmon is vital to the continued existence of the species and the social, economic, and cultural values that follow. We do not miss what we never knew and restoring connections can be much more difficult than maintaining existing ones. Along the way, values and perceptions will change, but ensuring continuity is critical. Restoring cultures and social conduct that depend on salmon can be done after a few failed seasons, but as time passes it becomes more difficult and knowledge is lost. A better monitoring of key measures of social, economic and cultural values associated with wild Atlantic salmon is necessary if important costs and benefits of salmon management, exploitation and conservation should be taken into account in a period of rapid environmental and social change. In a NASCO context key monitoring data that is often missing is good, consistent data on a yearly basis on the number and volume (effort) of participants in different fisheries and other non-consumptive uses of salmon (e.g. viewing, information/interpretation centers), as well as credible estimates of the total economic value of wild Atlantic salmon across the North Atlantic. Together with existing monitoring of catches, licenses and gear, this will provide a far better basis for assessing salmon's contribution to people.

It is now critical to better and more systematically document people's connections with emblematic species such as wild Atlantic salmon, and managers stand to gain important support by listening in. With many voices talking its case, wild salmon can persist even in a rapidly changing world.

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8 Appendices

8.1 Appendix 1 – glossary

Source: Gardner Pinfold 2011

The economic input-output analysis calculates how the initial spending (output) flows through the economy triggering demand for a myriad of goods and services. Following conventional practice, the economic impact is measured with three indicators:

- **GDP**: an industry's contribution to Gross Domestic Product represents its broadest measure of economic impact. The domestic product of an industry captures the value it adds to purchased inputs through the application of labour and capital. GDP represents the sum of the value added by each industry. GDP is typically lower than the gross output (spending) since many goods and services are brought in from other parts of the country and abroad. GDP represents the value that stays in within each province or region.
- **Income**: this captures payments in the form of wages and salaries (and shares of revenue in the case of fishing vessel crews) earned in the affected industries. Returns to labour in the form of wages, salaries and earnings form a key component of GDP. Industries paying relatively high average wages and salaries generate a correspondingly higher economic impact than industries paying lower average incomes.
- **Employment**: industry employment is important politically because of the significance generally attached to jobs, but from an economic impact perspective, the significance lies in the economic impact generated through the spending of employment income. The greater the employment and higher the average income, the more significant the industry in terms of economic impact. Employment is measured in full-time equivalents (FTE).

Economic impacts are generated through direct, indirect and induced demand in the economy expressed in terms of industry and consumer purchases of goods and services.

- **Direct impact**: refers to impact arising from the expenditures made by firms in the subject industries on the goods and services needed to produce industry outputs. For example, the fishing industry buys nets and traps from manufacturers; water transportation buys fuel from refineries.
- **Indirect impact**: refers to the inter-industry purchases triggered by the direct demand. For example, net makers buy monofilament line from manufacturers; refineries buy services from maintenance contractors; catering companies buy basic food products. These industries in turn buy more basic goods and services, and so on.
- **Induced demand**: refers to the demand created in the broader economy through consumer spending of incomes earned by those employed in direct and indirect activities. It may take a year or more for these rounds of consumer spending to work their way through an economy.

The sum of impacts flowing from each level of demand gives the overall economic impact of Canada's marine sectors. Generally, the greater the domestic supply capability at each level, the greater will be the economic impact. Conversely, the higher the import content, the weaker the domestic industry response (multipliers) and the lower the impact.

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8.3 Appendix 3 – geographic overview of literature

Table A1. Geographic location of studies retrieved in the literature search (2009-2019). See the text for details about the search. Note that all of these studies were not deemed important for this report.

Country or region	# studies
Baltic	4
Canada	3
Canada, France, Germany, Norway, Sweden	1
EU, Portugal, Spain, United Kingdom	1
Finland	1
France	1
Ireland	2
Not relevant (independent of geography)	8
Norway	9
Norway, United Kingdom, Germany	1
United Kingdom	6
United Kingdom, Ireland	1
United States	1
World	2
Total	**41**

8.4 Appendix 4 – geographic distribution and type of values

Table A2. Geographic distribution of studies found between 2009 and 2019 and which values were assessed.

Country or region	Cultural	Economic	Social	Economic & social	Economic & social	Economic, social & cultural	Social & cultural	NA
Baltic		**1**	**1**	**1**		**1**		
Canada	**1**		**1**					**1**
Canada, France, Germany, Norway & Sweden								**1**
EU, Portugal, Spain & United Kingdom			**1**					
Finland				**1**				
France						**1**		
Ireland		**1**				**1**		
Not relevant (independent geogr.)								**8**
Norway		**2**	**3**	**2**		**1**	**1**	
Norway, United Kingdom & Germany							**1**	
United Kingdom		**2**	**2**	**1**	**1**			
United Kingdom & Ireland				**1**				
United States				**1**				
World		**1**				**1**		
Grand Total	**1**	**7**	**8**	**7**	**1**	**5**	**2**	**10**

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Norwegian Institute for Nature Research
NINA head office
Postal address: P.O. Box 5685 Torgarden,
NO-7485 Trondheim, NORWAY
Visiting address: Høgskoleringen 9, 7034 Trondheim
Phone: +47 73 80 14 00
E-mail: firmapost@nina.no
Organization Number: 9500 37 687
http://www.nina.no

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