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Wild and Farmed Arctic Charr as a Tourism Product in an Era of Climate Change

Guðrún Helgadóttir[1], Hans Renssen[2], Tom Robin Olk[2], Tone Jøran Oredalen[2], Laufey Haraldsdóttir[3], Skúli Skúlason[4] and Helgi Þór Thorarensen[4,5]*

[1] Department of Business and IT, USN School of Business, University of South-Eastern Norway, Bø, Norway, [2] Department of Natural Sciences and Environmental Health, Faculty of Technology, Natural Sciences and Maritime Sciences, University of South-Eastern Norway, Bø, Norway, [3] Department of Rural Tourism, Hólar University, Hólar, Iceland, [4] Department of Aquaculture and Fish Biology, Hólar University, Hólar, Iceland, [5] Norwegian College of Fishery Science, Faculty of Biosciences, Fisheries and Economics, UiT the Arctic University of Norway, Tromsø, Norway

The topic investigated is the social-ecological system of Arctic charr (*Salvelinus alpinus*) fishing and aquaculture as a tourism product in an era of climate change. Arctic charr is a resilient salmonid species that was traditionally an important part of the sustenance economy in Arctic and Subarctic communities as a source of fresh food throughout the year. Arctic charr populations have declined in recent years, in part due to climate change. These changes in the freshwater ecosystems in turn affect the cultural and economic traditions of freshwater fishing and consumption. This development has consequences for the tourism industry as hunting, fishing and consuming local and traditional food is important in branding tourism destinations. Fisheries are no longer the source of this important ingredient in the Nordic culinary tradition, instead aquaculture production supplies nearly all the Arctic charr consumed. In this paper, we pool the resources of an interdisciplinary team of scholars researching climate change, freshwater ecology, aquaculture and tourism. We integrate knowledge from these fields to discuss likely future scenarios for Arctic charr, their implications for transdisciplinary social ecosystem approaches to sustainable production, marketing and management, particularly how this relates to the growing industry of tourism in the Nordic Arctic and Subarctic region. We pose the questions whether Arctic Charr will be on the menu in 20 years and if so, where will it come from, and what consequences does that have for local food in tourism of the region? Our discussion starts with climate change and the question of how warm it is likely to get in the Nordic Arctic, particularly focusing on Iceland and Norway. To address the implications of the warming of lakes and rivers of the global north for Arctic charr we move on to a discussion of physiological and ecological factors that are important for the distribution of the species. We present the state of the art of Arctic charr aquaculture before articulating the importance of the species for marketing of local and regional food, particularly in the tourism market. Finally, we discuss the need for further elaboration of future scenarios for the interaction of the Arctic charr ecosystem and the economic trade in the species and draw conclusions about sustainable future development.

Keywords: arctic charr (*Salvelinus alpinus*), climate change, aquaculture, tourism, food in tourism, fisheries, social ecological system

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Stacy Michelle Philpott,
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****Correspondence:***
Guðrún Helgadóttir
gudrun.helgadottir@usn.no

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INTRODUCTION

This is a conceptual study underpinned by the notion of socio-ecological system (SES) that Ostrom (2009) describes as a platform to gather, analyze and organize knowledge derived from different scientific areas. Guimarães et al. (2018) argue that extending such interdisciplinary research from the academic community to other sectors results in a transdisciplinary approach that lends itself to addressing sustainability issues. A solid knowledge base is important to engage trans-sectoral participation, define the problem and address it.

The SES in question is not an ecosystem in the conventional sense as a place-based entity but rather a value chain. The research problem is that of climate change impact on the value chain of Arctic Charr in regions of the North Atlantic. More narrowly defined the relationship of climate change and freshwater ecosystems; with the Arctic Charr, a species traditionally harvested for food and a local tourism product, as a case in point. We bring together and integrate knowledge from tourism, marketing, climatology, ecology, fish biology and aquaculture to provide a base for the discussion of viable future scenarios for the Arctic charr value chain in an era of climate change. This combined overview of recent research is a foundation on which to develop scenarios that may or may not, go against the grain of social representations of the relations between tourism, climate change and sustainability (Moscardo, 2012). This can contribute to knowledge-based action to meet the UNWTO goal: "Adapt tourism businesses and destinations to changing climate conditions" (2009, p. 11). A truly transdisciplinary project needs a sound epistemological foundation across fields of study and/or disciplines.

While climate change has become one of the key issues in discourses on tourism sustainability even to the extent of overshadowing other sustainability concerns (Moscardo, 2012), the dynamics of climate change, biodiversity and the tourism value chain is rarely considered. Research on tourism and climate change focusses on impacts and mitigation rather than an exploration of relations, networks and the interface between tourism and other industries (Prideaux et al., 2013; Jenkins, 2017). This is a heritage of instrumentalism noted in the research on sustainability issues in general. Tourism sustainability discourses have been described as limited to conservation of resources without recognizing that resources are "a complex and dynamic concept, evolving with changes in the needs, preferences and technological capabilities of society" (Liu, 2003, p. 461). An implication of this is to conceptualize nature as a dynamic context or system, rather than simply as the venue for tourism or as a service/experience scape (Margaryan, 2018). To do this, tourism research needs to be inter- if not transdisciplinary and applying mixed and/or multi-method approaches (Farrell and Twining-Ward, 2005; Becken, 2013; Khoo-Lattimore et al., 2019).

Tourism in the Nordic Arctic and Subarctic region has grown fast in terms of tourist arrivals, and so have the impacts of tourism on economies, societies and environment. Social ecosystem issues such as these are an under researched aspect of the tourism development, which needs to be addressed from a broad knowledge base to inform sustainability measures such climate change adaptation. "As climate defines the length and quality of tourism seasons, affects tourism operations, and influences environmental conditions that both attract and deter visitors, the sector is considered to be highly-climate sensitive" (UNWTO, 2009, p. 2). Climate change is of particular importance for Arctic tourism due to rapid change and perceivable impacts, which may affect the availability and supply of traditional local food.

Kelman (2009) talks of twin concerns regarding climate change and tourism in the Arctic: "The possible impact of climate change that may affect the viability of the tourism activities and the impact of tourism activities on the natural landscape" (2009, p. 96). The latter concern may be exasperated by the increased access to the Arctic envisioned by Valsson (2009). Increased demand for the region as a tourism destination as the temperatures approximate what is desirable in tourism, is one of the conclusions of Nicholls and Amelung (2015).

Typical tourism concerns pertain mostly to the physical impact of tourism on the destination, the presence of tourists in fjords and mountains bringing emissions, garbage and sewage into the region. Our interest lies in a rarely considered aspect, how the value chain of a species, including food and recreation in tourism is impacted by climate change. This is an important aspect as tourists are people with a basic need for nutrition. In the service economy and not the least in the experience economy logic, needs should not just be met, but transformed into an integral part of the tourism experience (Prebensen et al., 2018).

Arctic charr was traditionally an important source of food in the Arctic and Subarctic. Seasonal catches of Arctic charr were a staple in the diets of indigenous people such as the Inuit and Sami peoples (Johnston, 2002; Casi, 2020). Arctic charr is widely presented as local and traditional Nordic food. An interest in authentic food experiences is part of the global trend in tourism to search for "the local" where food and food culture are central in that context (Jönsson, 2013). The concept "local food" embraces a relation to a place and is ideologically connected to values such as environmental protection, biodiversity, social responsibility and fair trade (Sundbo, 2013). This makes local food an essential agent in tourism and destination development.

We will articulate the roles Arctic charr plays in tourism, as a local food provided by aquaculture and as an attraction in recreational freshwater fishing. We review recent research on climate change, that is global warming in the Arctic before moving on to discuss the effects this has on Arctic charr growth and production and we further elaborate the emerging threats that are associated with higher water temperatures. Then we integrate the implications for Arctic charr in freshwater ecology, aquaculture and tourism concluding with outlining possible future scenarios for further elaboration.

MATERIALS AND METHODS

We conducted a literature survey for each of the following topics: Climate change in the Arctic, Freshwater ecology of Arctic charr, Arctic charr aquaculture, food in Nordic tourism, Tourism and climate change and Arctic Charr as a tourism product. Each

group of experts wrote a narrative review of the state of art on their particular topic, which the author team reviewed and commented. Based on these reviews, we suggest potential future scenarios for the Arctic Charr SES and the implications discussed and presented as avenues for tourism marketing and product development around Arctic Charr in the Nordic Arctic and Subarctic region.

The global warming scenarios used here are based on the greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its latest assessment report published in 2014. These trajectories have been applied to drive global climate models within the so-called 5th Coupled Model Intercomparison Project (CMIP5), producing quantified estimates of temperature change around the world. The estimates of warming in the Arctic discussed in this paper is based on this CMIP5 output.

TEMPERATURE CHANGE IN THE ARCTIC

The first question we posed is; how warm will it get in the Arctic? Worldwide temperature measurements provide clear evidence for global warming during the past century, with temperatures having increased by more than 1°C relative to the preindustrial era in the late 1800's (Morice et al., 2020). This warming has been particularly expressed in the Northern Hemisphere extra-tropics, (to which the Nordic Arctic and Subarctic belong) where this rise in temperature exceeded 1.5°C. These changes have not been linear. A first warming phase between about 1900 and 1940 was followed by a period with stable conditions and even slight cooling that lasted until around 1980. Since then, Northern Hemisphere extra-tropics have experienced pronounced warming. This warming has been stronger in winter than in summer. The year 2016 was the warmest year on record and 2020 a close second (GISTEMP Team, 2020).

These three phases can also be recognized at a regional level, although the expression can be different in terms of degree of warming and timing. If we compare Iceland with Norway, clear differences are evident. For instance, in Reykjavik, Iceland, the warming exceeds the signal for the Northern Hemisphere extra-tropics, with mean annual temperatures increasing by 2.5°C in the last 100 years. Here, the seasonal contrast is as expected, with warming of more than 3°C in winter over the last 100 years, but around 2°C in summer. The timing in Reykjavik was also different from the hemispheric data, with the early warming phase continuing into the 1940's, while the second phase ended later, with the 1980's being still relatively cold. In contrast, in Norway, the annual warming over the last century was more similar to that for the Northern Hemisphere extra-tropics. However, there are substantial differences within this country, with the northern parts of Norway having experienced stronger warming since 1900 (around +2°C annual mean) than the south (around +1.5°C).

IPCC has used numerical climate models to make projections about future climate change, based on different scenarios for anthropogenic greenhouse gas emissions. According to these model results, annual mean temperatures will further increase in the decades to come, depending on the used scenario (Collins et al., 2013). In their fifth assessment report, the IPCC applies four different greenhouse gas concentration trajectories, referred to as "representative concentration pathways," or RCPs. These four RCP-scenarios are RCP2.6, RCP4.5, RCP6 and RCP8.5. The RCPs represent different global socio-economic scenarios, and their names reflect the radiative forcing (in $W \cdot m^{-2}$) in 2100 relative to preindustrial levels. RCP2.6 represents a decrease in the global greenhouse gas levels in the 21st Century following the Paris Agreement of 2015, whereas RCP8.5 implies an extreme scenario with a continuous rise in greenhouse gas emissions. For Iceland, the climate models project an additional annual mean warming compared to the present level ranging between +0.5°C (RCP2.6) and +3°C (RCP8.5). The high-end projections for SE Norway are a bit more extreme with +4°C for RCP8.5.

This prognosis raises the question what does it mean for Arctic charr? To address this question we provide a background on the species to explain how it will likely respond to a warming climate both in nature and in aquaculture.

ARCTIC CHARR AS A SPECIES

Distribution

Arctic charr have the northernmost distribution range of any fish species (Klemetsen et al., 2003). It has circumpolar distribution throughout the Arctic and into the temperate zone (Maitland, 1995; Klemetsen et al., 2003; Klemetsen, 2013). As glaciers receded during the end of the Pleistocene, some 11 thousand years ago, Arctic charr colonized emerging freshwater systems in their wake (Maitland, 1995). The success of Arctic charr as a pioneer species depends in part on their ability to survive and grow at lower temperatures than other freshwater species (Brännäs, 1992; Siikavuopio et al., 2010) as well as possessing significant phenotypic plasticity that allows them to acclimate rapidly to and exploit very different habitats (Klemetsen, 2010). Some populations of Arctic charr spend their entire life cycle in freshwater while others are anadromous and migrate to seawater for feeding during the summer months, but all spawn in freshwater lakes and rivers (Klemetsen et al., 2003). Watersheds with stable conditions opened possibilities for ecological specialization and evolutionary adaptations of separate populations to different habitats. As a result, many lakes possess two or more phenotypically and genetically distinct morphs of Arctic charr that differ in behavior, size and shape and utilize different niches, but in many cases descend from a single postglacial invasion of a founding population (Wilson et al., 2004; Gössling et al., 2012).

Population Trends: Effects of Climate Change, Diseases and Commercial Catches

There are indications that Arctic charr populations are declining. Indeed, since the 1980s, catches of anadromous Arctic charr in rivers in Norway (Svenning et al., 2012, 2016) and Iceland are reduced (Malmquist et al., 2009; Jeppesen et al., 2012; Thordardottir and Guðbergsson, 2017; Thordardóttir and

Gudbergsson, 2020). In the United Kingdom and Ireland, Arctic charr populations have declined and several populations have gone extinct (Maitland, 1995; Winfield et al., 2010). The decline is clearly related to various anthropogenic factors such as eutrophication, damming, afforestation, and exploitation; however, it is likely that climate change is also an important factor (Maitland, 1995; Klemetsen et al., 2003; Winfield et al., 2010).

The mechanisms by which climate change affect the decline of Arctic charr populations can be varied (Crozier and Hutchings, 2014). Thus, increased temperatures may primarily affect charr distribution by compromising egg and embryo development or through increased disease load as temperatures increase. The temperature limits for development of good quality eggs during the summer and especially in the autumn, just prior to spawning, are between 8 and 12°C (Gillet, 1991; Jeuthe et al., 2013, 2015; Olk et al., 2019; Imsland et al., 2020) and the thermal limits for successful ovulation are under 10°C. Temperature requirements for embryonic development are even lower, e.g. 4–6°C (Skúlason et al., 1989; Gillet, 1991) and, therefore, increased temperature during the summer, autumn and even into winter can contribute to reduced recruitment of juveniles that may contribute to the decline of populations. A second factor that can contribute to reduced numbers of Arctic charr is increased disease load with increasing temperatures. Thus, Proliferate Kidney Disease (PKD), caused by the myxozoan endoparasite *Tetracapsuloides bryosalmonae*, has been an emerging disease in freshwater salmonids in the northern hemisphere for the last three decades (Burkhardt-Holm et al., 2005; Kristmundsson et al., 2010; Okamura et al., 2011; Svavarsdottir, 2016; Bruneaux et al., 2017; Mo and Jørgensen, 2017). Water temperatures exceeding 15°C over several days, stimulated the proliferation of *T. bryosalmonae* and outbreaks of PKD (Hedrick et al., 1993; Tops et al., 2009; Okamura et al., 2011; Bruneaux et al., 2017; Mo and Jørgensen, 2017). With climate change, outbreaks of PKD are expected to increase in the future.

Furthermore, warming of Arctic charr habitats has considerable ecological effects, which can contribute to unfavorable changes, e.g. in charr mobility patterns (Goyer et al., 2014) and different competitive situations with incoming species. For example, the decline in anadromous Arctic charr populations in NV-Iceland has been paralleled with rising numbers of sea-run brown trout (*Salmo trutta*) in these systems (Ferguson et al., 2019; Thordardóttir and Gudbergsson, 2020). It is clear that with increasing temperatures, many habitats that the Arctic charr now occupy will become inhospitable for the species and the catches of wild fish will decline in many regions of the Nordic Arctic and Subarctic. However, the decline of wild populations does not have a major effect on the availability of Arctic charr on the menu. Most of the commercially available Arctic Charr is already farmed and will be in the future as the aquaculture production of the species is growing.

Commercial catches of Arctic charr have never been large but during the 19th and early 20th centuries, Arctic charr was pickled and canned in the Canadian Arctic, Labrador and Greenland for export to Europe (Johnston, 2002). Similarly, between 1939 and 1987, the pelagic charr morph (*murta* in Icelandic), from the Icelandic lake Þingvallavatn, was caught and canned mainly for export (Snorrason et al., 1992). FAO reports catches of wild Arctic charr from 1963 to 2018 (FAO, 2020), however, these records are likely incomplete. For example, catches in Canada are only recorded in 2018 (69 MT) which is odd and may suggest that recreational and sustenance fishing is under reported. Therefore, Arctic charr fisheries may be somewhat higher than suggested by the FAO reports (Johnston, 2002). There are peaks in catches for example in France in 2012 (283 MT) and in Sweden in 2015 and 2016, 419 and 310 MT that may represent over 20 fold increase from previous or following years. Thus, the total reported annual catches range from 63 MT to 419 MT with an average of 186 MT.

ARCTIC CHARR AQUACULTURE

Arctic charr have proven to be ideal for aquaculture in Nordic countries: Growing better at lower temperatures than other freshwater species and tolerating high rearing densities (Brännäs, 1992; Brännäs and Wiklund, 1992; Jobling et al., 1993; Brännäs and Linnér, 2000; Siikavuopio et al., 2010; Sæther et al., 2013, 2016; Imsland et al., 2019). The rapid growth of aquaculture in recent years has had its opponents and the discussion has been in the media (Schlag, 2011; Bacher, 2015; Froehlich et al., 2017). Among the main issues raised against aquaculture are the environmental impacts of waste from fish farms and the potential effects of mixing of aquaculture fish with wild populations.

Arctic charr in Iceland is primarily produced in intensive land based flow-through farms. Most of these farm use brackish water 7–12°C for the production. The Arctic charr production in Sweden is primarily in net cages set up in oligotrophic lakes that are reservoirs for hydropower production (Sæther et al., 2013). In Norway, Arctic charr is also produced in cages in lakes as well as in land-based systems. In Iceland, Sweden, and Norway, selective breeding programs are in place for Arctic charr. The total production of Arctic charr has increased progressively since 1987, and for 2019 it can be estimated 8300–8500 MT. The main producers are Iceland (∼60%), Sweden (∼27%), Norway (5%), Canada (3%), and Austria (3%). Other countries reporting Arctic charr production in recent years are Italy, Latvia, USA and the UK. The companies producing Arctic charr are very small compared with the large multinational companies in salmon farming. In Iceland, over 90% of the production comes from three companies and in Sweden the production is dominated two companies. Only one Arctic charr farm in Iceland has successfully branded its production and some smaller farms add value to their production by smoking the fish. In Norway, there are several smaller producers. Most of the production in Iceland is for export, while in other countries it is mainly for the domestic market.

As is the case for wild populations, increased ambient temperatures have affected Arctic charr production in Sweden (Jeuthe et al., 2013, 2015, 2016) and in Scotland primarily by increasing mortalities during the early developmental stages. However, chilling of rearing water for brood fish and incubation of eggs may remedy the problem. Survival rates during early development stages of aquaculture Arctic charr in Iceland, where temperatures are lower, are consistently higher than in Scandinavia.

Increasing and fluctuating temperatures may compromise the flesh quality of both wild and aquaculture fish. Relatively small differences in temperature (<5°C) are enough to elicit these changes (Ginés et al., 2004; Imsland et al., 2020). Arctic charr in many lakes develop a muddy off-flavor during the late summer due to accumulation of geosmins in the flesh. This can also occur in farmed charr where recirculating aquaculture systems are used for the production (Houle et al., 2011), although purging the fish in good water for a week or two will remove the off-flavor. Lower temperatures (<10–12°C) promote better quality in terms of freshness, color, and texture (Ginés et al., 2004; Imsland et al., 2020). Professional taste panels determined the quality of the charr in these studies, but the differences are likely large enough for the average consumer to discern. This can also create seasonal differences in quality where the annual rearing temperatures fluctuate with higher quality in winter than in summer. The quality of Arctic charr in recirculating aquaculture systems, that operate at a relatively high temperature and with little water exchange, may also be impaired (Houle et al., 2011). However, negative effects of high temperature on flesh quality may be mitigated by short term starvation before slaughter (Imsland et al., 2020).

The aquaculture of Arctic charr has primarily developed in Nordic and Alpine countries where climate conditions are favorable and the species is part of the local and traditional diet. Therefore, both environmental and cultural factors have contributed to the growth of Arctic charr aquaculture. In fact, one of the main challenges of marketing charr is that international markets are not very familiar with the species and its superior quality. Most of the production in countries other than Iceland is for the domestic market, including restaurants that cater to the tourism market. Essentially all Arctic charr available in stores or on the menus of restaurants, offered as new Nordic food, are farmed.

Given that aquaculture is the main source of Artic charr it will remain on menus in the future although wild stocks may decline. However, it is not clear to what degree increased temperature may affect the flavor and quality of Arctic charr. Given the importance of the species as a local food in the domestic market, this should be seen in context with the seasonality of the market, notably tourism as a market for Arctic charr. This leads us to consider the trends in tourism that make Arctic charr interesting as a case.

ARCTIC CHARR IN THE TOURISM MARKET

Recreational activities in nature such as fishing are an important part of the product portfolio of tourism in the Nordic, Arctic and Subarctic regions. Seasonality is a defining trait of tourism in the regions: "As climate defines the length and quality of tourism seasons, affects tourism operations, and influences environmental conditions that both attract and deter visitors, the sector is considered to be highly-climate sensitive" (UNWTO, 2009, p. 2). Summer has been the high season of tourism in the region, but over the decade 2009–2019 winter tourism has doubled, leaving the shoulder seasons of spring and fall as the low season.

Water ecosystems are a resource in tourism as an attraction for a wide range of water based activities, which will be affected by climate change. The quality of the water, its ecosystem, the spatial/geological and aesthetic qualities of the waterway are important to keep the standard of the attraction (Gíslason et al., 1999; Sun and Hsu, 2019). This applies in niche tourism products such as angling tourism and lake tourism where wild Arctic charr is a resource. In Iceland, about 1.4% of international tourists say that they have gone fishing during their visit, which makes it one of the least popular outdoor recreational activities. In contrast, 8.5% of domestic tourists went fishing, making it one of the most popular activities (Ferðamálastofa, 2016).

The Arctic charr is a case supporting the claim that "Animals as food or as food for animal attractions is one of the most, if not the most, significant and pervasive use of animals in tourism" (Lamoureux, 2018, p. 2). While this is true, recent trends in tourism show an increased interest in tourism experiences that afford an opportunity for learning and growth (Prebensen et al., 2018). In this regard, it must be noted that nature is the main tourist attraction in the region (Fredman and Tyrväinen, 2010). Nature based products and services for tourists range from consumptive such as fishing and food tourism, to non-consumptive such as watching wildlife. An important aspect of nature-based tourism is educational and meets the need of an interested and well-educated audience for natural scientific information and inspiration. Which means that a local species is not only of interest as prey or food, but also as part of natural and cultural heritage.

The Arctic charr is of great importance as natural heritage and affords the opportunity to educate about developmental and evolutionary ecology. Winfield, Berry and Iddon account for the recognition of the cultural importance of Arctic Charr heritage for the Windermere. They speak of a shift from the Arctic Charr as "a provisioning ecosystem service in the form of food for local and distant human populations, to now providing a range of cultural ecosystem services encompassing cultural, spiritual, historical, recreational, and educational dimensions" (Winfield et al., 2019, p. 17). This potential for tourism product development is yet to be developed in the Nordic Arctic and Subarctic region where Arctic charr has so far mainly served as a food product.

Bessière pointed out already in 1998 that rural areas were seen as places for entertainment and leisure for urban residents, and that local food and food tourism presented economic potential for rural communities (Bessière, 1998). The tourism market craves healthy, uncontaminated and locally produced if not wild, food (Counihan and Van Esterik, 2016). The destination marketing campaigns for the Nordic countries and the North Atlantic over the last decades have focused strongly on meeting the culinary demands of this market. A case of this is the salmonid fish Arctic charr (*Salvelinus alpinus*), which today is common on the menu of restaurants in the region, often presented under the banners of New Nordic Food, Slow food or regional and local food labels.

In consumer tests and with professional taste panels, Arctic charr scores consistently higher than either Atlantic salmon (*Salmo salar*) or rainbow trout (*Oncorchynchus mykiss*) due to its

milder flavor and texture (Johnston, 2002). In the words of Mrs Beeton, in her classic 19th century English cookbook:

> The Char—This one is the most delicious of fish, being esteemed by some superior to the salmon. It is an inhabitant of the deep lakes of mountainous countries. Its flesh is rich and red, and full of fat. The largest and the best kind are found in the lakes of Westmoreland, and, as it is considered a rarity, it is often potted and preserved. (Beeton, 2000).

Over the last couple of decades, national and regional agencies have implemented food tourism initiatives to attract tourists and promote places (Hall et al., 2003; Sims, 2010; Everett, 2012, 2016). Crossing national borders in the Nordic region, local food and place was at the center when The Nordic Council of Ministers kicked off the project New Nordic Cuisine in 2005. It was a "follow up" of the New Nordic Cuisine manifesto, launched in 2004 in Copenhagen, by a group of Nordic chefs. At that time, Nordic chefs generally became more aware of regional and local food and more visible in international contests such as the Bocuse d'Or competition, a biennial famous cooking award held in Lyon, which until then had mostly been won by French chefs (Nordic Council of Ministers, 2015). The New Nordic Cuisine manifesto embraces purity, season, ethnics, health, sustainability and quality—features attributed to the Nordic food. This joint Nordic project was systematically developed and promoted to strengthen the Nordic countries as a worthwhile tourism destination, and to give the Nordic cuisine, suffering a rather negative perception at the time, a new image (Haraldsdóttir and Gunnarsdóttir, 2012).

The criticism that the idea of New Nordic Cuisine was to a great extend borrowed from the Nouvelle Cuisine (and the Slow Food movement) did not ring loud (Leer, 2016). Shared cultural roots, a political image of democratic, liberal welfare states and geographical location were applied, with emphasis on the robust unbridled Nordic nature fostering clean and fresh ingredients. Low temperatures, short light summers and long dark winters create an important frame in the discourse, where Nordic climate and soil was supposed to sustain a unique characteristic in the Nordic food (Haraldsdóttir and Gunnarsdóttir, 2012; Leer, 2016).

Turning to another highly important trend, local food in tourism, there is a market for both farmed and wild Arctic charr. The idea of food and the meal experience has changed over the last decades (Belasco, 2008; Trubek, 2008; Jönsson, 2013). According to the ethnographer Håkon Jönsson the search for "the local" is the most extended global trend today (Jönsson, 2013), food and food culture are central in that context. Contemporary middle class food consumer culture is highly engaged with ethical and environmental issues where consumption of local food fits perfectly in (Leer, 2016). There is however, a contradiction in the demand for the local food as it is dependent upon global forces, such as international tourism (Pétursson, 2013; Haraldsdóttir, 2015). Research has suggested that convenience and price play an important role in the decision of purchasing organic, fair trade or local food on everyday basis (Sims, 2009). Thus, in order to be ethical and environmental friendly people travel and buy local food, some to support local communities, many to satisfy their desire to try something new and exotic as well as to experience local traditions through food (Haraldsdóttir, 2015; Leer, 2016). It should however be noted that while people are very positive toward purchasing and consuming local food when traveling, there is a gap between intention and consumption that can partly be explained by lack of marketing and branding of local products (Birch and Memery, 2020). This makes local food an essential agent in socially and culturally sustainable tourism and destination development.

DISCUSSION

The rising temperatures alter the whole ecosystem from the reproduction of Arctic charr in the wild to the experience of tourists visiting destinations in the Arctic and Subarctic. The disappearance of ice and snow, which changes the visual experience of landscapes and the plight a few wild species such as the Polar bear have caught attention. Warming climate drives species north, but the effect of climate on fish that are popular tourist products has hardly been discussed. Concerns over wild Atlantic salmon for instance focus more on perceived threat from salmon farming than on climate change as a contributing factor to decline in wild stock.

Warmer waters are a threat to the Arctic charr affecting both their reproductive cycle, pressure from pests and diseases and competition (Skúlason et al., 1989; Gillet, 1991; Okamura et al., 2011; Jeuthe et al., 2013, 2015; Olk et al., 2019; Imsland et al., 2020). To answer the question of how warm it will get in the Arctic we have the prognosis of rising temperatures by +0,5°C to +4°C (IPCC,) but the rise will most likely not be linear over the next 20 years. Furthermore, there will be regional and local variations and microclimates depending for instance on water source, level of glacial melting and depth of lakes.

These variations present an opportunity for the Arctic charr due to its plasticity and resilience through rapid adaptation to diverse habitats (Klemetsen, 2010). Nevertheless, it is safe to assume that because of warmer climate, wild populations will disappear from many waterways and that Arctic charr fishing will diminish even further.

This does not mean that Arctic charr will become extinct and disappear from the menu. The Arctic charr consumed in the world comes to the largest extent from Arctic charr aquaculture (FAO, 2020). While warmer waters may pose difficulties for farming in lakes, the land-based production in closed systems is less sensitive to climate change. It is therefore possible to preserve local stock through cultivation.

The aquaculture production will secure an abundant year-round supply of Arctic charr in the future. In contrast, commercial catches of charr are small and seasonal. The supply of farmed charr is likely to increase while wild populations will likely decline further. Increasing temperatures may affect aquaculture production of Arctic charr where rearing temperatures are over 10–12°C, although chilling water, where possible, during critical production stages may ameliorate this effect. The method used to produce the charr determines the effects of climate change on the production. Where charr is produced in tanks at relatively

low temperatures with well water of good quality, the effects of climate change on the production will be minimal. In contrast, the effect of climate change will be much greater when the charr are produced in cages in lakes or reservoirs where the ambient temperature can be comparatively high during the summer.

Arctic charr is marketed as pure traditional Nordic food with references to the cool, pristine waters of the region. The traditional supply of Arctic charr was through fisheries, but nearly all the charr prepared for tourists comes from aquaculture. This raises questions regarding authenticity and the suitability of farmed Arctic charr as a substitute for wild fish. Are customers seeking local and traditional food ready to accept farmed charr instead of wild fish? Consumer choices are complicated when it comes to choosing and buying fish (Rickertsen et al., 2017; Pulcini et al., 2020). Price, quality, nutritional value and health concerns are important, but also ethical issues such as sustainability of production and welfare of fish (Regnier and Bayramoglu, 2017; Banovic et al., 2019; Reig et al., 2019). Consumers are also a very diverse group and their attitude to aquaculture varies considerably (Bacher, 2015; Froehlich et al., 2017). Therefore, it is likely that the acceptance of farmed Arctic charr as a replacement for wild fish will vary among consumer groups and it is not at all clear if this is a major issue for restaurant customers. Given the findings of Birch and Memery (2020) this depends much on the marketing information to customers.

The environmental impacts of Arctic charr farms depend on the production methods. Cages are open and, therefore, uneaten feed and feces from fish will increase the organic load from the fish farms. This can lead to more organic productivity in oligotrophic reservoirs (Eriksson et al., 2010). Escapes from the net cages and the mixing of aquaculture fish (from breeding programs) with wild populations present certain risks. However, strict regulations about fish farming in the Nordic countries require environmental impact assessments that estimate the potential risks with regards to nutrient loading and risks to wild populations (Young et al., 2019). The environmental impact of land-based aquaculture is less than from cages in lakes and the sea. Filtering of the effluent from the farms removes organic particles and the probability of escapes from tanks is much lower than from cages. These issues are actively debated for Atlantic salmon aquaculture (Bacher, 2015; Froehlich et al., 2017; Young et al., 2019), but much less or not at all for Arctic charr farming. Therefore, it is not clear how important these opinions are when customers make their choices from Nordic menus.

There are no studies comparing consumer preferences for wild or farmed Arctic charr. Consumers may have preconceived ideas about the quality of wild and aquaculture fish, and in many cases consumers believe wild caught fish to be healthier and of better quality than aquaculture fish (Kole, 2003; Kole et al., 2003; Rickertsen et al., 2017; López-Mas et al., 2021). However, there is no evidence that farmed fish are of inferior quality to wild caught fish although there may be differences in texture and other sensory characteristic (Kole et al., 2009). The quality of wild fish is likely to vary throughout the year due to temperature fluctuations being lower in summer than in winter. In addition, geosmins may impart unpleasant muddy flavor to the flesh during late summer, which is high tourism season in the Nordic Arctic and Subarctic region. Therefore, the quality of wild fish is lowest when most tourist are visiting the Nordic countries. The quality of farmed charr is more constant, especially where water temperature is low. Therefore, farmed Arctic charr are a better option for restaurants.

Arctic charr will remain a traditional food, rooted in the natural and cultural heritage of the region. Today the biggest producers operate in the Arctic and Subarctic region and their product can be labeled local in the region. However, it is possible in an era of globalization to move production elsewhere and this would be a threat to the branding of Arctic charr as integral to the New Nordic cuisine for example.

The Arctic charr is a species that is of great value in imparting knowledge about ecology, natural and cultural heritage. This aspect can be explored to a greater extent in nature-based tourism in the region. The climate change discourse in and around has lacked focus on important concerns such as loss of biodiversity, landscape and ecosystem changes and the social and cultural impacts (Farrell and Twining-Ward, 2005; UNWTO, 2009; Bock, 2016). The Arctic charr provides a good case in point for these factors.

CONCLUSION

This review suggests that Arctic Charr as a local, traditional food in the Nordic Arctic and Subarctic region will be increasingly in demand in a growing market, both domestic and tourist that craves local, sustainably produced and healthy food. This is however, only one of the three main roles that Arctic charr can play in tourism. It is to a limited extent prey for tourists who like to fish it; it is a popular local and traditional food and it is of great interest as natural heritage.

Typical tourism concerns in the Nordic Arctic and Subarctic center on the physical impact of tourism on the destination, the presence of tourists in fjords and mountains bringing emissions, garbage and sewage into the region. Our interest lies in a rarely considered aspect, tourism and the food chain. This is an important aspect as tourists are people with a basic need for nutrition. In the service economy and not the least in the experience economy logic, needs should not just be met, but transformed into an integral part of the tourism experience as culinary tourism and nature-based tourism. The characteristics of the Arctic charr, the great plasticity and resilience are factors that could feature in product development. That is, the natural history of the Arctic Charr might both be conceptualized as an attraction in itself through nature and natural heritage based tourism as educational tourism and as an added value to the food experience.

Among the research gaps that we have identified are: (a) better measuring and modeling of how biological and physical systems in water will change as a consequence of climate change; (b) measures and models of how the industries using Arctic charr as a resource; aquaculture and tourism will be impacted. Such data will enable the formulation of scenarios and actions in response to these changes. One area of likely change is the species mix as species move, adapt or become extinct from ecosystems as they become warmer. For the Arctic charr this presents a scenario of

an even narrower distribution further north, at higher altitudes and in deep lakes. From an evolutionary ecology perspective, monitoring how Arctic charr adapts in the current climate crisis may have significant implications.

Further research is also needed on the economic impacts of climate change on the industries using Arctic charr. For aquaculture, a future scenario will likely involve increased effort and resources devoted to controlling water temperature and water quality. The pen aquaculture in lakes is more vulnerable to the warming climate than closed land-based systems, which will have implications for the economic prospects of the sector.

This review suggests a path forward in research and practice that answers the call for a closer collaboration between tourism researchers and natural scientists in exploring what climate change might mean for Arctic charr, aquaculture and tourism.

AUTHOR CONTRIBUTIONS

GH: corresponding author, conceptualization, wrote the abstract, discussion and conclusions, coherence between sections and general editing of the manuscript according to the journal style as well as co-authoring the Arctic Charr in the tourism market section. HR: conceptualization, authored the section on climate change. HT: conceptualization, authored the section on Arctic charr and aquaculture and contributed to the section on tourism and Arctic charr as a species. LH: co-authored the section on Arctic charr and tourism, marketing of arctic charr as part of destination branding and arctic charr as local food. SS: conceptualization, contributed to the chapter of Arctic Charr as a species, worked on coherence between sections. TRO: co-authored the section on Arctic Charr as a species and reviewed referencing for the whole document. TJO: co-authored the of the section on Arctic charr as a species. All authors contributed to the article and approved the submitted version.

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