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“Public perceptions of pink salmon in Norway and willingness to pay for the current eradication management program”

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Picture by Katherine Mary Dunlop@HI

Abstract

Since 2017, Norway has experienced a large influx of Pacific pink salmon (*Oncorhynchus gorbusha*), and this species occurrence has created challenges for society, businesses, the environment, and policymakers. However, there is currently no consensus on whether pink salmon is a new resource or a pest in Norway. While some people perceive pink salmon as a food resource and a good recreational fishing species, others consider that pink salmon as a threat to local salmonids and ecosystems. Therefore, to deal with the pink salmon problem the Norwegian authority has implemented a management measure to eradicate pink salmon from Norwegian rivers. This study investigated the acceptance of Norwegian recreational anglers of the current eradication programme on pink salmon invasion. It also explored the perception of Norwegian anglers to the arrival of pink salmon and its associated effects. A semi-structured questionnaire was developed and conducted to collect data among Norwegian anglers. The contingent valuation method (CVM) was employed, and the Tobit model was fitted to evaluate the respondents' willingness to pay (WTP) for the eradication measure. The results (n=267) demonstrated that half of the respondents advocated the eradication programme and their mean WTP is about NOK 607. However, 67% of respondents were unwilling to pay to contribute to this management program because most anglers indicated that the government should bear complete financial responsibility for the management initiatives related to environmental resources. The factors that significantly influenced the respondents' WTP were anglers' fishing experience, their attitudes towards pink salmon management regimes, the co-management approach, and respondents' perception of pink salmon as a new resource or a pest. Socioeconomic characteristics such as age, education, income, and membership in professional organizations do not statistically significantly influence the WTP. This study provides the first research insights into the perspectives of anglers and the general public on pink salmon and the current eradication program. Results can assist policymakers in mitigating the stakeholders' conflicts by designing effective and efficient management measures to governing pink salmon arrival in Norway.

Keywords: pink salmon invasion, contingent valuation, willingness-to-pay, recreational fisheries, anglers, perception, eradication management, Norway.

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1 Introduction

Globally invasive species have recently attracted attention and creating challenges for society, businesses, and policymakers (Rolfe & Windle, 2017; Hanley & Roberts, 2019). According to Keller *et al*. (2011), non-native species become invasive when they are introduced, become established and cause negative impacts on the surrounding environment. Furthermore, alien species can have the potential for detrimental ecological impacts on native species and ecosystems that can be associated with far-reaching socio-economic repercussions (Larson *et al*., 2011; Estevez *et al*., 2015; Crowley *et al*., 2017; Santos *et al*., 2019). Considering that ecosystem services, namely provisioning, regulating, supporting, and cultural (MEA, 2005), are an essential part of human well-being the invasive species issue falls within the scope of both management actions and common society awareness and participation (Garcia-Llorente *et al.*, 2011). Living organisms have always been transported beyond their natural range unintentionally as well as intentionally introduced in new areas to solve socio-economic challenges (Perrings *et al*., 2000; Bardsley & Edwards-Jones, 2007; Matishov *et al*., 2011). However, increased anthropogenic pressure coupled with global climate change have recently accelerated the spread of non-native species as well as changed their migration routes globally (Bardsley & Edwards-Jones, 2007; Karabanov & Koduknova, 2015; Santos *et al*., 2019). The relocation of alien species has been evident in impacts to ecosystem functions and services (Garcia-Llorente *et al.*, 2011; Keller *et al*., 2011).

Thus, the environmental implications of invasive alien species (IAS) have received significant attention from both ecologists and economists (Larson *et al*., 2011). Keller *et al*. (2011) argue that alien species are perceived as one of the major threats to vulnerable aquatic biodiversity, predominantly freshwater habitats. Invading species can have deleterious effects on native ecosystems and local species by competing for food and habitat, spreading diseases, increased native species predation, and changing the food web and community structure (Westman, 1998; Garcia-Llorente *et al.*, 2011; Katsanevakis *et al*., 2014; Sandlund *et al*., 2019; Dahl, 2020). All these negative consequences are alarm signals of accelerating biotic homogenization, causing biodiversity reduction that negatively affect human well-being (Garcia-Llorente *et al.*, 2008; Hanley & Roberts, 2019; Levers & Pradhananga, 2021).

The existence of alien species has corresponded with depleted native fish stocks, low catches, decreased income, and increased unemployment in aquatic sectors such as fisheries or the aquaculture industry (Katsanevakis *et al*., 2014). However, society can also benefit from the

occurrence of non-native species, especially from a utilitarian perspective. For example, economic benefits can be created by recreational fishing of non-native fishes as well as augmented provisional services (Garcia-Llorente *et al.*, 2011; Carrilo-Flota & Aguilar-Perera, 2017; Kocovsky *et al*., 2018; Cid-Aguayo *et al*., 2021). Substantial advantages of utilizing non-native species that have high fecundity and economic value, specifically fishes, have been identified (Bardsley & Edwards-Jones, 2007; Cid-Aguayo *et al*., 2021).

Garcia-Llorente *et al. (*2008) state that while some industries and ecosystems suffer from invasions, other sectors profit from the new environmental circumstances. In addition, the alien species can improve the chemical properties of the soil as well as transport nutrients toward local ecosystems and provide native biota with food (Mdweshu & Maroyi, 2020; Cid-Aguayo *et al*., 2021; Dunlop *et al*., 2021a, b). Usually, alien species have a low probability of becoming a pest, because only 10% of introduced (non-captive) species become established in new areas, and only 10% of those become a pest (Williamson, 1996). However, at the same time they have unpredictable, abrupt, and inconstant behaviour traits that can reduce the effectiveness of amassed scientific knowledge and experience to cope with them (Ben-Haim, 2017). With this in mind, it is crucial to identify the proper, effective, and efficient management responses to tackle the influx of alien species and reduce the harm to the social capital (Larson *et al.*, 2011).

Invasive species management (ISM) is complex and comprises knowledge provided by scientists, resource management, economists, and the public (Simberloff *et al*., 2013). ISM´s primary goal is to detect, prevent, or eradicate alien populations as well as to mitigate invasion impacts on local ecosystems and people´s well-being (Simberloff *et al*., 2013; Crowley *et al*., 2017). Besides, the human and social dimensions have recently been recognised as an inherent part of effective resource management and conservation, including ISM (Garcia-Llorente *et al*., 2008; Meyer & Fourdrigniez, 2019; Shackleton *et al*., 2019a; Shackleton *et al*., 2019 b). Generally, the ISM objectives of effective management programmes are founded on a complete understanding of people's use and non-use values related to local ecosystems as well as public perceptions of potential risks associated with alien species (Bardsley & Edwards-Jones, 2007; Estevez *et al*., 2015; Lew, 2015). Hence, the ISM must be considered as a scientific issue as much as a social (Bremner & Park, 2007). Moreover, effective ISM measures are those that are supported and mutually agreed by all relevant stakeholders (Estevez *et al*., 2015; Crowley *et al*., 2017; Shackleton *et al*., 2019 b). Different stakeholders, including management bodies, can have distinct or somewhat controversial perspectives on alien species, and exclusion or neglect

of relevant stakeholders can lead to social clashes and results in resistance towards management (Larson *et al*., 2011; Estevez *et al*., 2015).

For example, the invasive Chinook salmon has caused controversy and a conflict of interests between recreational, artisanal fisheries and the salmon farming industry in Chile (Cid-Aguayo *et al*., 2021). Another case related to an invasive fish species was registered in Mexico and described the stakeholder perceptions of red lionfish (*Pterois volitans*). Divers, fish consumers, and restaurant owners valued this species differently in terms of the economic and culinary perspective (Carrillo-Flota & Aguilar-Perera, 2017). In both cases, the findings from research on public perception of invasive species significantly contributed to mitigating the stakeholders' conflicts by selecting the appropriate management options.

Therefore, as demonstrated in these case studies, it is critical to have the full support and collaboration of the public, especially resource users, when it comes to implementing the invasive species eradication programs that are costly and require specific legislation (Bremner & Park, 2007). Moreover, some public fractions can experience ethical concerns regarding this management measure (Simberloff *et al*., 2013a; Estevez *et al*., 2015). To date, many ISM control or eradication programmes have been delayed or failed due to polarised public attitudes and perceptions regarding alien species (Mdweshu & Maroyi, 2020).

1.1 Research objectives

This research is the first attempt to explore the perceptions, and opinions of fishers and the general public to the influx of pink salmon in Norwegian rivers as well as investigate their attitudes to the current management measures regarding eradicating pink salmon from Norwegian rivers. The pink salmon issue is a current matter of urgency as the interests of many relevant stakeholders are at stake. The specific research objectives include a) to evaluate the willingness to pay (WTP) for a national management program that focuses on pink salmon eradication from Norwegian rivers among Norwegian anglers and the general public; b) to examine and evaluate the current state of knowledge on pink salmon among anglers and the general public; and c) to evaluate and compare the perceptions of anglers and general public regarding pink salmon occurrence and existence in Norwegian rivers.

1.2 Thesis structure

This thesis is organized as follows. Section 2 presents the background information on pink salmon's biological and ecological aspects, introduces the case of pink salmon in Norway and describes the salmonid recreational fishing in Norway and outline the scope of the problem related to pink salmon. Section 3 describes questionnaire design and the process of data collection. Section 4 introduces the data analysis methods, including justification of the CVM approach and the Tobit regression model application to analyse respondents' WTP. Section 5 presents the results, while Section 6 discusses the results and outlines the implications of the results. Section 7 is a conclusion including policy implications drawn from the WTP evaluation.

2 Pink salmon and recreational fishing in Norway

2.1 Pink salmon biology, ecology, and native distribution

Pink salmon (*Oncorhynchus gorbuscha*, Walbaum 1792) belongs to the genus *Oncorhynchus* within the Salmonidae family. Species in this family are characterised by high commercial importance (Altukhov *et al*., 2000). Among the Pacific salmonids, pink salmon have the smallest body weight combined with the highest growth rate and global abundance (Volobuev & Marchenko, 2011). In addition, this species has a strict 2-year lifecycle that gives rise to two distinct ecotypes, even- and odd-year populations (Pennell & Barton, 1996), that do not overlap in reproduction (Gorokhov *et al*., 2019). Scientific research has revealed that the fecundity is higher in odd-year populations than in even- years (Kirillova *et al*., 2018) and that these two ecotypes differ in terms of ecology, and morphology (Volobuev & Marchenko, 2011)[1].

As pink salmons are anadromous as well as semelparous species, meaning that their first life stage begins in freshwater (Altukhov *et al*., 2000), and mature fish migrate to spawn (Smirnov, 1975) between June and September depending on the region (Pennell & Barton, 1996). According to Groot & Margolis (1991), pink salmon prefer to spawn in the lower reaches of rivers. Entering the freshwater, pink salmon build redds to deposit the eggs. In this period,

[1] Generally, the fecundity of mature female pink salmon ranges from 1200 to 1900 eggs, depending on body size, region, population, climatic conditions (Pennell& Barton, 1996).

species can behave aggressively and fight for nests (Smirnov, 1975). Pink salmon prefer to spawn in beds consisting of gravel with a few large cobles, some amount of sand[2], and a small amount of silt (Groot & Margolis, 1991). A few weeks after spawning, both male and female species die and their carcasses can serve as fertilizers for the area around spawning grounds (Smirnov, 1975).

Successful eggs transform into alevins and stay in the gravel until the yolk sac is absorbed (Smirnov, 1975). Then they become fry and start migrating to the sea immediately, going through the smoltification period at the fry stage (Smirnov, 1975; Pennell & Barton, 1996). During seaward migration, the pink salmon fry can suffer from predation by native or non-native fishes, for example, Arctic charr (*Salvelinus alpinus* L.) (Groot & Margolis, 1991). Pink salmon juveniles prefer high caloric food such as zooplankton, especially krill[3] (Karpenko *et al*., 2007). Leaving freshwater, pink salmon stays in salt water for approximately 18 months (Groot & Margolis, 1991); where temperature and other climatic factors can impact the pink salmon survival during seawater migration (Altukhov *et al*., 2000). Adult pink salmon feeding in the sea also prefer plankton as well as crustaceans, squids, and juvenile fish (Shuntov *et al*., 2017; Shuntov *et al.*, 2019). After this period, species return to freshwater to spawn, showing a homing instinct (ibid). However, pinks are characterized by increased straying, therefore, Arctic Ocean warming can ultimately affect pink salmon distributions. This straying phenomenon in the Arctic is crucial to study to understand pink salmon potential to coexist with indigenous salmonids (Babaluk *et al.*, 2000).

In terms of morphology, mature males develop a dorsal hump as a secondary male sexual characteristic and large kype, and teeth (Smirnov, 1975). Before the spawning process, pink salmons are bright silver with small scales, and become darker, particularly in the dorsal zone, closer to spawning. Other characteristics of pink salmon are the black tongue and gums[4] , as well as a caudal fin and dorsal surface covered with large oval black spots.

The native range of pink salmon is expansive and embraces the Arctic and the Pacific coastal waters, from the Sacramento River in northern California to the Mackenzie River in Canada. In addition, this species exists throughout the territory from the Lena River in Russia to Korea

[2] The large percentage of sand components decreases eggs' likelihood of survival (Groot &Margolis, 1991).
[3] https://www.pac.dfo-mpo.gc.ca/fm-gp/salmon-saumon/facts-infos-eng.html (accessed 23.01.22)
[4] https://www.nina.no/english/Biodiversity/Alien-Species/Pink-salmon (accessed 23.01.22)

and Japan (Groot & Margolis, 1991; Sandlund *et al*., 2019). Several introductions' programmes were conducted in the Great Lakes in Northern America and in the Soviet Union (Groot & Margolis, 1991). Because of the latter programme, pink salmon has been observed in the UK and the Republic of Ireland, Iceland, and Norway. In addition, global warming is thought to have already affected the pink salmon populations, expanding their natural areas (Babaluk *et al.*, 2000).

2.2 Pink salmon in Norway

Norway is facing a particular challenge in ISM with the case of the non-native Pacific pink salmon (*Oncorhynchus gorbuscha*, Walbaum 1792). Recreational salmon fishing is of high importance to many Norwegians, and the arrival of pink salmon has put the industry (Toivonen *et al*., 2004; Liu *et al*., 2019; Kochalski *et al*., 2019) at the risk of economic loss (Mo *et al*., 2018; Sandlund *et al.,* 2019). Concerns exist that pink salmon can potentially affect the native species and local environment, including competing for spawning grounds and food with local salmonids, and contaminating freshwater and riverbanks with pink salmon carcasses (Sandlund *et al*., 2019).

Starting in 2017, at least 272 Norwegian rivers have experienced the influx of pink salmon (Mo *et al.,* 2018; Sandlund *et al*., 2019). The scientific explanation of why this species arrived in such great abundance remained uncertain (Mo *et al.,* 2018). However, scientific opinions include climate change affecting the productivity of Arctic ecosystems (Dunmall *et al*., 2013) and the recent successful pink salmon spawning in Norwegian rivers are commonly suggested reasons amongst local communities (Mo *et al.,* 2018; Sandlund *et al*., 2019).

According to records, pink salmon has been constantly observed in Norway since 1960 (Rasmussen, 1961; Bjerknes & Vaag, 1980). With high likelihood, it can be claimed that pink salmon has existed in Norwegian rivers for several decades because of the two-stage introduction programme initiated in 1956 and terminated in 2000 in the Russian North (Zubchenko *et al.,* 2010) that borders Norway. This species was selected for this acclimatization program owing to its high economic and protein value in Russia as well as relatively simple and low-cost catch methods (Shuntov *et al*., 2019; Ryzhkova & Kruchinina,

2020[5]). The paramount goal of this programme was to naturalize pink salmon in the White Sea basin to enhance catches in this area (Zubchenko *et al*., 1998) not endowed by many commercially valuable fishes (Berger *et al*., 2001) but enriched by zooplankton and benthic communities (Berger *et al*., 2001; Alekseev *et al*., 2006).

Generally, there is scarce information on pink salmon total catches in Norway until 2017, when the pink salmon invasion was announced (Sandlund *et al*., 2019). The first pink salmon seawater and freshwater catch[6] statistics were recorded in Norway in 1975 which revealed the odd year populations were more abundant than the even years´ populations both in the salt and freshwater environments (Bjerknes & Vaag, 1980). According to Hopkins (1998), there were no pink salmon catch records in 1990. Limited activities were conducted to measure the abundance of migrant species across the country (Sandlund *et al*., 2019). However, "Naturtjenester i nord" carried out scientific works to register the pink salmon occurrence in the Finnmark´s rivers in the period 2001-2017 (Naturtjenester i nord, 2018).

More than 11000 pink salmon entered Norwegian rivers in 2017, mainly invading Northern Norway, where approximately 10000 individuals were caught and observed (NINA, 2017; Mo *et al*., 2018; Sandlund *et al*., 2019). This number was obtained by "recruiting" the general public and fishers to record pink salmon catches by employing the Facebook platform where people were invited to post photographs of caught pink salmon (Sandlund *et al*., 2019). Furthermore, it has been announced that fishers are obliged to report pink salmon catch starting 2019[7].

Despite sparse available of scientific information assuming the negative impact of pink salmon on native salmonids and local ecosystems (Mo *et al*., 2018; Sandlund *et al*., 2019; VKM, 2020; Vitenskapelig Råd for Lakseforvaltning[8], 2021) this species has been announced as a high-risk invasive species in Norway in 2018 (NBIC, 2018). In addition, the Norwegian Scientific Advisory Committee for Atlantic Salmon (VRL) ranked pink salmon as an impact factor on wild Atlantic salmon populations characterised by poor knowledge and high uncertainty (VRL, 2018). Hence, Norwegian authorities have implemented the eradication

[5] According to the Russian Federal Agency for Fisheries, the overall commercial catches of Pacific salmons reached 540 000 tons in 2021, which becomes one of the largest Pacific salmon recorded catches.
[6] Freshwater catches were recorded on the Tana River, which is one of the largest salmon rivers in Europe (Dahl, 2020).
[7] According to SSB, the number of caught pink salmon is seven times more in 2021 than in 2019, constituting 111 657. In terms of total weight, 190 686kg of pink salmon was reported in 2021, which is eight times more than the catches of 2019 and by 6% exceeds yields of 1977. Due to the rule novelty and potential for unreported and illegal yield, catch statistics can be inaccurate.
[8] Vitenskapelig Råd for Lakseforvaltning hereinafter VRL

program to remove all pink salmon coming to national rivers[9][10]. VKM[11] (2020) informs about different methods employed to eradicate pink salmon, particularly harpoon, Hawaii sling spear, electrofishing, seine nets and gill nets, during 2017-2019 in Norway. Strategies to mitigate pink salmon after spawning were also conducted and included labour-intensive works, such as the removal of spawning redds. Besides, VKM (2020) identified more drawbacks than benefits of this method. Therefore, the active removal of spawning redds is still under discussion.

However, there is currently no consensus on whether pink salmon is a new resource or a pest in Norway. Recent scientific studies revealed the pink salmon have the potential to enrich local poor-nutrient ecosystems with energy and provide food for scavengers. However, more research is required to identify which species benefit and which species suffer from the pink salmon carcasses (Dunlop *et al.*, 2021b). In addition, Nofima, a leading Norwegian food research institute[12], has announced pink salmon flesh and roe potential for the food industry. Moreover, some Norwegian anglers have also acknowledged pink salmon as a good dietary product[13], while a fraction of professional fishers foresee the demand for this species will soar. However, certain fishing organizations have struggled against pink salmon to protect native salmonids, which are staples of their economy[14]. As for now, the Norwegian government continues[15] employing the costly eradication measure that has not yet achieved its primary goal.

A high level of uncertainty of the risks associated with pink salmon and a low level of knowledge have been the current focus of public debate. While scientists and government bodies have met to present empirical findings, the public have used social media groups to discuss this matter and share their own experiences and opinions on pink salmon. Despite the recognised importance of understanding socio-economic perceptions for ISM systems, there are currently no research regarding the socio-economic perspective of pink salmon in Norway among the general public and fishers.

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[9] https://www.nrk.no/tromsogfinnmark/pukkellaksen-brer-om-seg-_-stor-trussel-for-norge-1.15577083 (accessed 23.02.22)

[10] https://www.fiskeridir.no/Akvakultur/Nyheter/2021/hastetiltak-mot-pukkellaks (accessed 23.02.22)

[11] VKM (Vitenskapskomiteen for mat og miljø)

[12] https://nofima.no/resultater/pukkellaksen-er-en-ypperlig-matfisk/?fbclid=IwAR2_G1W-JneVCocxh6p5TvORPTovkdmMUTKxvDiHlwW1ZHSiFvHPUQ3_kKY (accessed 23.02.22)

[13] https://www.nrk.no/tromsogfinnmark/_-pukkellaksen-er-en-ypperlig-fisk-a-spise-1.13609698 (accessed 15.03.2022)

[14] https://www.fiskeribladet.no/fiskeri/laksefiskere-haper-pa-kommersielt-fiske-av-pukkellaksen-vi-klarer-aldri-fa-bukt-med-den/2-1-1044900 (accessed 18.03.2022)

[15] https://www.njff.no/aktuelt/15-millioner-til-bekjempelse-av-pukkellaks (accessed 23.02.22)

2.3 Salmonid recreational fishing in Norway

Norway is a Scandinavian country located in Northern Europe with a total freshwater area of 16 360 km^2 (Bevanger, 2021), most of which is available for inland fisheries, including recreational salmonid fishing (Aas & Kaltenborn, 1995). According to the SSB (Statistisk sentralbyrå), the total population in Norway comprises about 5,4 million people[16] in 2021. Approximately 32% of the whole population participate in recreational fishing in various ways (Arlinghaus *et al.*, 2015), showing one of the highest per-capita participation in the recreational fishery among the industrialized countries (Aas & Kaltenborn, 1995). Recreational salmonid fishing has become deeply embedded in the lifestyle of many Norwegians (Colman *et al*., 2008) as well as being perceived as an important part of the national and local economy (Toivonen *et al*., 2004) creating income for local communities and fishing tourism enterprises (Stensland *et al*., 2021).

All fishers older than 18 years are obliged to register and buy the license to fish salmonids in freshwater[17] in Norway as well as they should pay a certain fee to local landowners to fish (Colman *et al*., 2008). In total, Norwegian fishers have access to more than 400 salmon rivers in Norway, a part of which has recently been affected by the pink salmon influx (Forseth *et al.*, 2017; Stensland *et al.*, 2021). The state owns approximately half of the Norwegian area (Toivonen *et al*., 2000), with 98% of Finnmark under state ownership (Bjerknes & Vaag, 1980) where two of the largest salmon rivers in Europe are located: Tana River and Neidenelva[18]. These rivers, coupled with the Alta River, lure national and international wealthy and passionate fishers. In 2014, some fishers spent around NOK 30 000 ($ 5000)[19] per day to fish local salmonids on the Alta River[20]. Considering additional expenditures on special equipment, fuel, outdoor clothes, booking lodging, and buying food (Colman *et al*., 2008), salmon rivers significantly contribute to state and local economies throughout the fishing season.

Generally, the fishing season lasts from the 1st of June to the 31st of August and varies from river to river, and approximately 70 000 anglers spend around two weeks fishing. This includes

[16] https://www.ssb.no/en/befolkning/folketall/statistikk/befolkning (accessed 04.02.22)
[17] https://www.miljodirektoratet.no/publikasjoner/2019/mai-2019/national-fishing-fee/ (accessed 26.01.22)

[18] Tana river is one of the largest salmon rivers in Europe (Dahl, 2020). 70% of the river belongs to Norway, 30% -belongs to Finland. Neidenelva- 8% belongs to Norway, 92% belongs to Finland (Sandlund *et al*., 2019).
[19] This sum is the average of the overall costs related to the fishing trip.

[20] https://www.newsinenglish.no/2014/07/17/alta-salmon-river-lures-the-wealthy/ (accessed 19.03.2022)

foreign tourists, who account for about one-fifth of this number (Stensland *et al.,* 2021). The most targeted salmonids during the fishing season are the Atlantic salmon (*Salmo salar* L.), brown trout (*Salmo trutta* L.), and the Arctic charr (*Salvelinus alpinus* L.) (Liu *et al*., 2019; Stensland *et al*., 2021).

Due to the Atlantic salmon stocks having suffered mass die-offs because of increased anthropogenic activities (Forseth *et al.,* 2017) and climate change (Liu *et al*., 2019) in the past decades, special regulations have been imposed on recreational salmon fishing to improve salmon fish stocks in 2009 (Stensland *et al*., 2021). These measures have impacted the fishers´ satisfaction in different ways, therefore, the number of fishers registered in Norway has declined (Stensland *et al*., 2021).

The emergence of pink salmon in Norwegian rivers may bring about both challenges and opportunities for recreational fishing. For example, according to previously conducted studies, Norwegian anglers are harvest-oriented fishers (Aas & Kaltenborn, 1995; Liu *et al*., 2019; Stensland *et al*., 2021); therefore, the pink salmon abundance could potentially satisfy an essential aspect of the fishing trip for those who catch fish to consume. Besides, there are many Norwegians, especially younger generations, who have been employing the catch-and-release method, and they also can benefit from pink salmon existence in Norwegian rivers (Liu *et al*., 2019; Stensland *et al*., 2021). However, specific biological characteristics and the unstudied pink salmon's potential to harm local salmonids and change ecosystems are hurdles to announcing pink salmon undoubtfully being a new recreational salmonid fishing resource. Anyway, despite the dwindling salmon resources and stricter regulations, the number of official members of the largest interest organization promoting fishing and hunting across Norway to people of all ages and genders, namely the Norwegian Association of Hunters and Anglers (NJFF), increased by 5.5% in 2021 compared to 2020 and constitutes 116120 members[21]. There have become more people in the association that probably have different expectations from a fishing trip.

[21] https://www.njff.no/aktuelt/kraftig-vekst-hos-norges-jeger-og-fiskerforbund?fbclid=IwAR3afCVbSnFcUGE3770VLzqarcmMWLm3Gh2NkXT_zOxPmAdqNoZJL22aIPg (accessed 26.01.22)

3 Methodology and materials

3.1 Questionnaire design and data collection

Data collection was undertaken using an online questionnaire from 16.09.21 till 11.01.22, to coincide with the end of the 2021 fishing season. 267 responses to the questionnaire were received. The respondents´ demographics were well representative in age, gender, education, income, fishing experience, and geographical location which match SSB in Norway and other surveys of recreational anglers (Liu *et al.,* 2019).

Questionnaires as a data collection method has been widely used to research the social perception of invasive species (Kapitza *et al*., 2019) and quantify human perceptions or attitudes (White *et al*., 2005). The questionnaire was of a semi-structured design comprising of 32 questions (Appendix 1). In addition, there was an introduction presenting the background information to respondents and one open question (Q33) for any additional information which respondents would include and was though missing from the questionnaire and answers. The questionnaire included four main parts: (1) respondents' attitudes to pink salmon as species and their level of knowledge regarding it; (2) respondents´ attitudes toward the current management programme and their willingness to pay to eradicate pink salmon; (3) respondents fishing practice, preferences and motivation; (4) sociodemographic characteristics.

In general, all questions were close-ended with multiple-choice, or a 5-point Likert scale choice, ranging from "strongly disagree" to "strongly agree" with the mid-point being "neutral", but an open question "Other" was also given for those who wanted to elaborate more on the question and answers. A question of willingness-to-pay (WTP) for contributing current management program (eradication) was also included. The questionnaire was made using the Microsoft Forms application. The questionnaire was pre-tested by an expert group of researchers (4 – 6) who had given essential suggestions and comments to greatly improve the questionnaire. Then it was proofread before sending out.

Respondents' level of experience, attitudes, and knowledge on pink salmon. The first section focused on the individual anglers´ experience and attitudes towards pink salmon and their understanding of the species. Respondents were asked whether they had ever caught pink salmon and liked its taste. Next, they were asked whether they minded catching pink salmon instead of native salmonids and how they perceive the fishing trip given pink salmon existence in Norwegian rivers. Then, as the humans´ actions are often interpreted by the level of their knowledge, respondents were asked whether they knew what caused pink salmon to migrate to

Norway, what are the potential consequences associated with pink salmon in Norway, and the major threats to local resources and ecosystems. Respondents were also asked to choose whether the pink salmon could co-exist with local ecosystems and whether pink salmon was a new resource that can facilitate recreational fishery recovery and serve as a food resource. People were also asked what source of information they prefer to use and whether they considered the current level of scientific data to be sufficient to make effective management actions. These questions on experience, awareness, and knowledge of the pink salmon were also crucial in perceiving the quality of the information provided in the second section determining the WTP level (Nikodinoska *et al*., 2014).

Respondents' attitudes toward management. The second section of the questionnaire included questions about the respondents´ perceptions to current management measures and co-management proposal coupled with the question designed to reveal the respondents´ potential to volunteer to remove pink salmon from rivers.

The WTP question was included in this section to determine respondents´ WTP to fund the current eradication program. People were asked whether they agreed to pay an annual contribution to support the eradication program ("*Would you be willing to contribute financially towards pink salmon eradication?*"). Respondents´ WTP was explored by employing a continuous increment payment card (PC) with six different offers (NOK00.00, NOK500, NOK1000, NOK2000, NOK5000, NOK10000), from which respondents chose one amount that they would pay annually to contribute to the eradication programme. Payment amounts were clearly defined based on the test-study results, the literature, and conversations with academic specialising in recreational fishing, ensuring that relevant budget constraint were outlined (Arrow, 1993). However, an open option was also available for those who were not satisfied with the payment card and explained their choice and their amount to pay. This open choice is very important since more than half of respondents were not willingness to pay and some of which gave the reason for their choices (see results).

The third part of the questionnaire addressed respondents´ fishing experiences, habits, and motivation. Not only did this section help understand how active fishers were and what species they targeted during the fishing season, but this section also provided the variable that characterized the potential implicit social and individual factors affecting the WTP (Garcia-Llorente *et al.,* 2011).

Respondents' socio-demographic characteristics. The fourth part of the questionnaire was designed to elicit an understanding of the socio-demographic characteristics as well as respondents´ involvement in the professional and conservation organizations together with possible regional differences. Collected information was used as explanatory variables of the respondents´ WTP as well as to describe the anglers´ profile in Norway.

3.2 Survey administration

An online survey was used to gather data due to budget and time constraints (Johnson & Christensen, 2016). Given wide internet coverage (92% Norwegians use internet), the online questionnaire format was also convenient for respondents because the participants can complete the questionnaire at any time. The study held a particular interest for Norwegian angers who fish salmonids in rivers and fjords and are potentially affected the most by the pink salmon influx. General public opinion was also of interest to address the study objectives. Therefore, the questionnaire was distributed first through the Norwegian Association of Hunters and Anglers (NJFF) mailing lists, and other Norwegian organisations that sell fishing licences[22]. Later, the questionnaire link was also posted in national and local social media groups related to the recreational fishing and pink salmon issue via Facebook to ensure the heterogeneity of respondents. According to the statistics, Facebook is Norway's favourite online social media (Norsk mediabarometer, 2020). Thus, the respondents were randomly selected and not stratified sampled.

3.3 Data handling

Preliminary data handling included : 1) sorting the answers the respondents gave in the « Other» option of some questions; 2) converting character variables to numeric by replacing the answers with integers ; 3) replacing « Prefer not to say » answers for income and education with « Not Available ».

A quantitative analysis was used to calculate descriptive statistics and carrying out a Chi-square test of independence to check whether the variable *"Region"* was related to management perception variables or not. 90% of the pink salmon influx was observed in the Northern Norway, however the *Region* as a regressor for WTP was insignificant. However, the Chi-test of independence served as an additional analysis element to identify the potential association

[22] Emails of those persons could not be presented.

of *"Region"* variable with certain management variables. It was supposed that those people who faced the pink salmon problem more than others might have different perspectives on the management of the problem. The Chi-square test of independence was employed as chosen variables are categorical and only non-parametric tests can be used.

Descriptive exploration and analysis were performed in Excel, while statistical analysis was carried out using RStudio 2021.09.2+382 "Ghost Orchid" Release for Windows (RStudio Team, 2020). Tobit analysis used R package VGAM https://cran.r-project.org/web/packages/VGAM/index.html and AER https://cran.r-project.org/web/packages/AER/index.html, while graphs were produced using the package ggplot2 (Wickham, 2009). Other packages used: mosaic (Pruim *et al*., 2017), reshape (with the function revalue) (v0.8.8; Wickham, 2007).

3.4 Ethics statement

The Norwegian Centre for Research Data (NSD)[23] is an organisation whose primary duties are to advise researchers on data management, data storage, and data protection. The NSD were consulted, and the rules verified online, however this resulted in the outcome that an official ethics requirement were not required because the respondents were not able to be identified under the project design. However, the dataset was stored following UiT ´s (The Arctic University of Norway) data management plan. Moreover, the returned questionnaire was considered as inferred consent from the respondents, considering that anonymity and confidentiality are granted, and they were informed that the survey results would be used for scientific purpose, and published or presented at scientific conferences and workshops. All the data were coded anonymously before data analysis.

4 Data analysis

4.1 Contingent valuation approach

The contingent valuation method (CVM) was used for this study. CVM is a stated preference method to measure total economic value consisting of use and non-use values of goods and

[23] https://www.nsd.no/en/about-nsd-norwegian-centre-for-research-data/ (accessed 06.02.22)

services (Perman *et al*., 2011; Hanley & Roberts, 2019). This method is one of the most employed approaches to estimate the economic value, especially for non-market goods and services, such as recreational resources and environmental amenities (Mitchell & Carson, 1989; Nishizawa *et al.,* 2006; Olaussen, 2016) that have different benefits and costs (Toivonen *et al*., 2004).

Usually, CVM employs surveys built on the data collected through the questionnaire to obtain respondents´ opinions on hypothetical scenarios and elicit people´s preferences for public goods and services (common-pool resources), exploring what they would be willing to pay for particular improvements (Mitchell & Carson, 1989). To date, CVM has become a popular approach to evaluate environmental services worldwide (Toivonen *et al*., 2000; Rolfe & Windle, 2017). There is a rich literature on the CVM applications including measuring the economic value of recreational resources, WTP to measure the impacts of invasive species on ecosystem services and the protection of endangered marine species. For instance, Toivonen *et al*. (2004) employed the CVM to measure the economic value of recreational fishing in five Nordic countries by eliciting the non-use value of this activity using WTP questions. The study helped understand how the respondents' economic profiles affected the WTP, which was useful information for the economic viability evaluation of conservation projects. Dahal *et al*. (2018) used the CVM to estimate the WTP to preserve waterfront open spaces in the USA. This research indicated the proper balance between preservation and development of environmental resources for local economic activities. Nishizawa *et al.* (2006) applied the CVM to estimate WTP for decreasing alien fish stocks in Japan. The findings of this research were useful to define suggestions to obtain an adequate budget and work out a more comprehensive management program. Mwebaze *et al.* (2010) conducted WTP for a policy to protect local biodiversity from IAS (mammal predators) and justified the management programmes in the Seychelles islands. Garcia-Llorente *et al*. (2011) conducted CVM to identify the social factors affecting the WTP for ISM of certain aquatic and terrestrial plants, fish, crustaceans, reptiles, and birds with regards to two different regimes: eradication and prevention in Spain. The study implied that respondents' motivations influenced support or disagreement on ISM strategies, and the public approved ISM's huge budget to eradicate invasive species. Levers and Pradhananga (2021) revealed what exactly influenced the respondents´ WTP for local aquatic species lake management and what management strategies can help to obtain the public support for IAS management in Minnesota (USA). In short, the CVM has been widely used for IAS problems and associated management strategies. The economic valuations by using CVM could

significantly impact the management programmes and justify economic efficiency of management strategies. Therefore, to add more knowledge in this area, in this thesis, the CVM approach was used to elicit angers' preference to and their WTP for current management strategy to eradicate pink salmon from the Norwegian watercourse.

4.2 Tobit regression model

The Tobit model, also called a censored regression model, is a specification of regression models to account for mass points in a dependent variable that is censored somehow. It was first developed in 1958 by James Tobin (Tobin, 1958) and is commonly used in CVM research to describe the relationship between WTP (non-negative, limited-dependent variable) and a set of explanatory variables (Mcdonald & Moffitt, 1980; Yoo *et al*., 2001; Sale *et al*., 2009). As the WTP for a good or service is often characterised by the non-willingness of respondents to pay for their improvement, in such cases, their WTP is equal to zero (Yoo *et al*., 2001).

Since this study has a high proportion of zero WTP respondents (67%)[24], the standard ordinary least regression (OLS) is not appropriate because it fails to account for the qualitative difference between zero (limit) and continuous (non-limit) observations, resulting in inconsistent and biased estimates. Therefore, a solution was to use the Tobit model which is frequently suggested for such censored data in contingent valuation literature in recreational activities (Halstead *et al*., 1991; Cantrell *et al*., 2004; Chen *et al*., 2018). A standard Tobit model is written as:

$$y_i^* = \boldsymbol{\beta}' x_i + \mu_i, \ \mu_i \sim N(0, \sigma^2)$$

$$y_i = \begin{cases} y^* & if\ y_i^* > 0 \\ 0 & if\ y_i^* \leq 0 \end{cases} \qquad \text{i.e., } y_i = max\{y_i^*, 0\}$$

where y_i^* denotes latent dependent variable, $\boldsymbol{\beta}$ is a vector of coefficients to be estimated, and μ_i is a random error which is assumed to be normally distributed, $\mathbf{x_i}$ is the regressors matrix – independent variables.

[24] Some respondents didn't simply choose the « No » option but instead gave reasoning for their refusal to pay in the « Other » option of the response. I recoded those to « No ».

4.3 Variables

A total of eight independent explanatory variables representing respondents' attitudes to pink salmon, current management strategy, and its contributions, as well as social-economic demographics, were selected to estimate the WTP. For analysis purposes and logic, some of the variables were combined and re-grouped, especially those that included some information stated in the response option "Other" demonstrating respondents' opinions that were not presented in the given choices. The description of explanatory variables used in the Tobit model is listed in Table 1.

Resource_pest. The first variable labelled as *"Resource_pest"* indicated whether respondents perceived the pink salmon as a resource or pest. It is an important variable to affect respondents´ decision to support the eradication measure or not. Moreover, whether pink salmon is a resource or pest has been ardently discussed in Norwegian society recently, particularly among anglers.

Solution* and *Co-management. The second set consisted of two variables: *"Solution"* and *"Co-management"* which together demonstrate the respondents´ attitudes toward problem solutions and pink salmon management. *"Solution"* was measured with four different management regimes, while *"Co-management"* was measured with four different scenarios in terms of anglers´ participation in pink salmon management.

Experience. The third set of variables is named as *"Experience"* measuring respondents´ fishing experience in terms of the number of fishing years. It is expected that experienced anglers are likely to be more concerned about the resource they use and its quality; thus, anglers' experience influences the WTP.

Socio-demographic variables. The fourth set of variables included four sociodemographic variables *"Age"*, *"Education"*, *"Income"*, and *"Membership"*. The first three variables were chosen as sociodemographic characteristics were often included in the contingent valuation surveys assuming that social context could correlate with and influence WTP (Han *et al*., 2011; Chen *et al*., 2018; Dahal *et al*., 2018). The *"Membership"* was assumed to be a potentially significant variable affecting WTP decision as many Norwegians hold NJFF and other organizations membership.

Table 1. Description of variables used in the model to identify the WTP to eradicate pink salmon

Variables	Type	Description
Respondents´ attitudes to pink salmon and towards current management programme		
Resource_pest	Binary	Respondent´s perception whether pink salmon is resource or pest (1 = No, it is a problem/pest; 2 = Yes, it is a resource)
Solution	Nominal	The perception of management actions considering pink salmon existence in Norwegian rivers (0 = I do not know; 1 = Let them be in the rivers without doing anything; 2 = Fish them in the sea; 3 = Implement measures so that it can co-exist with other fish species in the river ecosystem; 4 = Totally remove them from the rivers)
Co-management	Nominal	The assessment of co-management proposal regarding pink salmon management (0 = I do not know; 1 = No, I do not like this idea at all, because it makes the situation worse; 2 = No, I do not think that can work; 3 = Maybe it can be an option; 4 = Yes, I like very much the idea to implement a co-management approach)
WTP	Numerical	WTP to fund eradication programme (values: 0, 500, 1000, 2000, 5000, 10000)
Respondents´ fishing experience		
Experience	Nominal	Fishing experience (1 = 1-4 years; 2 = 5-16 years; 3 = 17 and more years)
Socio-demographics		
Age	Nominal	Age (1 = 18-34 years, 2 = 35-54 years, 3=55 and older)
Income (NOK)	Numerical	Respondent´s income before tax in national currency (1 = under 500000; 2 = 500000-1 mill; 3 = 1- more than 1.5 mill). Prefer not to say is replaced with NA.
Education	Binary	Highest education level: (1 = up to bachelor's degree; 2 = master´s degree and higher. Prefer not to say is replaced with NA.
Membership	Binary	Membership in professional organizations (0 = Do not have membership; 1= Fishing and hunting clubs, and environmental organizations)

5 Results

5.1 Socio-demographic profile of the respondents

A total of 267 responses were received. Almost half (48%) were from Northern Norway, 41% of those responses came from Finnmark county residents, 32% and 27% came from Nordland and Troms counties, respectively. 21% of overall responses were obtained from people living in Western Norway, and 18% from Eastern Norway. 11% of overall responses were residents of Mid-Norway while only 2% of respondents came from Southern Norway.

The sociodemographic characteristics are described in Table 2. There was a higher proportion of male respondents (94% male *vs* 6% female). Most respondents were between 45 - 67 years of age (53%) with higher education (49%) or high school education level (35%). A minor fraction of respondents (4%) had a PhD degree. Most respondents were employed (84%), earning a regular income of NOK500 000 – 750 000 per annum (25%), with a lower proportion (7%) receiving an annual income higher than NOK1.5 million. Those who earned NOK750 000 - 1 million comprised 21% of all the respondents, the same share reported annual income at the level of NOK1 - 1.5 million.

Most people were employed in the private sector. 15% were service sector workers, 23% were employees of industries related to natural resources. Other industries, such as construction or maintenance, were the working place for 12% of respondents. Besides, one-fifth of overall respondents were public workers. Approximately 8% were engaged in science and 6% of respondents are workers at NGO organizations. Finally, 15% of respondents identified themselves as retired and 1% comprised of unemployed people. In terms of membership, most respondents held membership in fishing and hunting organizations (65%), while 4% reported membership in environmental organizations. A quarter of respondents had no membership.

Table 2. Descriptive demographics summary statistics

Variables	**Description**	**%**
Age	18-34	15
	35-44	22
	45-54	28
	55-67	25

	68 or older	10
Education	Secondary school	7
	High school	35
	Bachelor and Master´s degree	49
	PhD or higher	4
	Others	5
Income (NOK)	Less than 500 000	16
	500 000-750 000	25
	750 000-1million	21
	1-1.5million	21
	More than 1.5 million	7
	Prefer not to say	10
Membership	Fishing and hunting organizations	65
	Environmental organizations	4
	No members	25
	Others	6

5.2 Respondents' experience, attitudes, and knowledge on pink salmon

Most of the respondents have caught pink salmon (55%), 45% have not had any. Approximately half (48%) of the overall respondents liked pink salmon taste; however, 45% could not define their taste preference regarding this fish. Only 7% of respondents answered negatively about the pink salmon taste.

When respondents were asked whether they minded catching pink salmon instead of native salmonids in rivers, most respondents (53%) were opposed this fishing scenario. Moreover, approximately one-third of respondents (31%) said they would prefer to target native salmonids than pink salmon when fishing. Nevertheless, 10% of respondents preferred to fish pink salmon to reduce pressure on local anadromous species. Those hesitant about whether they minded fishing pink salmon accounted for 6% of all responses.

A large proportion (45%) of respondents considered the fishing trip unpleasant when asked how they could estimate their fishing experience when pink salmon was present in rivers. Surprisingly, some respondents (13%) found fishing activity more exciting because pink salmon contribute to larger biomass to catch. Fishing is about enjoying nature; therefore, there are no species preferences to target. This was the opinion of 21% of overall respondents who answered this question. The same fraction (21%) of respondents did not admit any changes in fishing practice.

Public awareness of why pink salmon came into Norwegian rivers was generally high. A high proportion (89%) of respondents associated pink salmon occurrence in Norway with anthropogenic activity, 11% of people explained the pink salmon existence in Norway as a natural climatic shift. Only two people said that they had no clue about this matter.

People need scientific information to decide whether pink salmon can co-exist in Norwegian rivers (41%). The current knowledge on pink salmon allowed 31% of respondents to consider pink salmon co-existence possible, including strict management control. Nevertheless, 28% of respondents did not think like that. Despite the lack of information on the pink salmon, 48% of people perceived pink salmon as a good food source and a proper recreational fishing resource to ameliorate the declined local salmonids stocks (8%). 44% of respondents considered pink salmon a hurdle to solve.

What is the reason for public concern over pink salmon? The Likert-scale question contained six response options (Figure 1). Competing for food and resources was ranked first (73%, both “strong agree” and “agree”) as possible consequences of pink salmon existence. In the long run, people were also concerned about native species´ damage due to alien diseases spreading (71%, both “strong agree” and “agree”) and potential pink salmon dominance in Norwegian rivers (71%, both “strong agree” and “agree”). Across all responses, it should be noted that one-third of respondents (30%) could not identify their attitude towards biodiversity loss due to pink salmon while one-fifth (20%) of respondents did not consider whether pink salmon caused any problems.

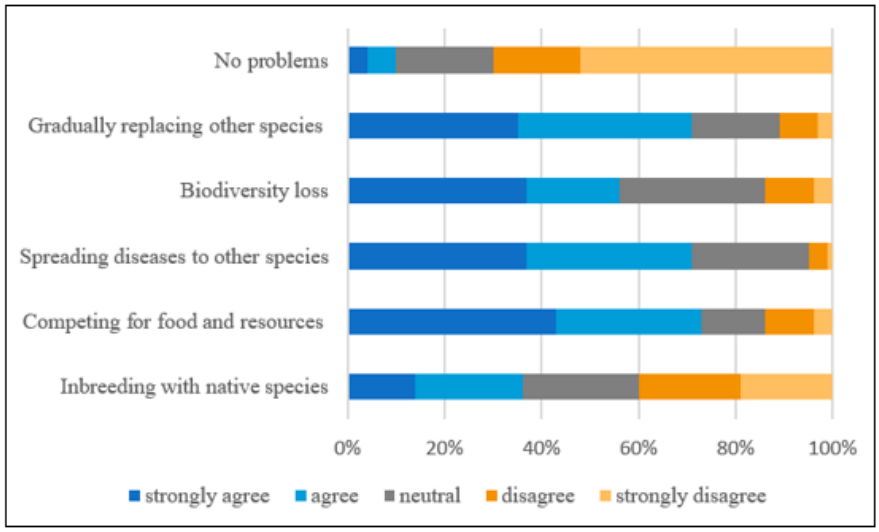

Figure 1. Environmental problems due to pink salmon arrival

Such respondents´ vague answers on ecological problems related to pink salmon could be explained by scarce information on this species. Most people (72%) revealed that information on pink salmon was not enough; only 18% of respondents stated that enough scientific information on pink salmon existed. 10% of respondents chose to answer, “I do not know”. In total, 58% of respondents obtained information related to pink salmon from scientific literature, while 42% trusted so-called grey literature, including social media, journals, books, TV, and radio. The pink salmon case has resonated powerfully with people, as many have discussed this species amid the family and working environment and referred to the official government sources to be abreast of the latest discoveries on pink salmon.

Most respondents (92%) believed that native salmonids are facing threats. Surprisingly, as one of the six Likert-scale responses offers, invasive species were not the severest threat to the native salmonids (Figure 2). The aquaculture industry was primarily attributable to indigenous salmonids' poor stock condition from the opinion of 82% of respondents (mostly "strong agree" 62%, "agree" 20%). The respondents also identified that overfishing and climate change heavily threaten local salmonids. When evaluating marine industries as a calamity ruining local salmonids stocks, nearly 43% of respondents did not elicit their opinion on whether this industry affected native anadromous species.

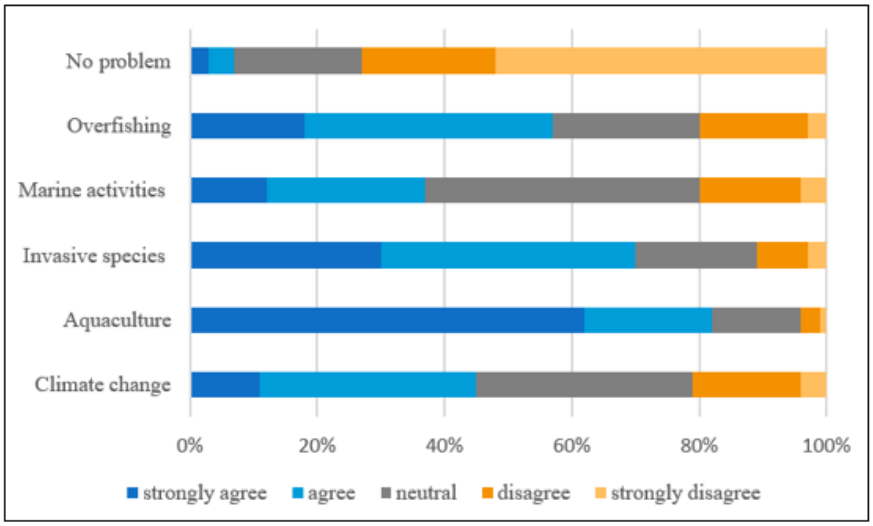

Figure 2. The main threats to the native salmonids

5.3 Respondents´ attitudes toward current pink salmon management

Respondents were asked what they wanted the management bodies to do with pink salmon arrival. Half of the respondents (51%) advocated the eradication programme, while 30% believed implementing alternative management measures could help the pink salmon population coexist within Norwegian biodiversity. Fewer respondents supported the idea of not intervening in natural processes (9%), and only 6% chose the "I do not know" response option.

The remaining 4% of overall responses constituted approximately 90% of those who shared opinions choosing the "Other" response option. The collective suggestion was "*Fish pink salmon in the sea*", but the *scientific advice* on how not to harm native anadromous species was lacking, and respondents strongly required it. Respondents also claimed that the society has already passed the tipping point regarding successful pink salmon eradication; therefore, the best solution for local fishing organizations was to receive financial support from the government to reduce pink salmon abundance. Some respondents considered it was especially crucial for northern Norwegian counties.

In terms of fishing communities and local people's involvement in decision-making, 82% fell in with this proposal. A negative attitude to the co-management suggestion was reported by 11% of respondents, while 7% of respondents hesitated to answer. In addition, despite the majority viewing co-management as a perspective regarding pink salmon management, people were concerned whether those public and fishing organizations possessed enough ecological

knowledge to decide. Conflict of interests between different stakeholders, poor current local organizations' salmon management, and lack of general national and local strategies to cope with the pink salmon arrival were among respondents' significant concerns delivered by the "Other" option. In addition, the Chi-square test of independence revealed the association that could be interesting to explore further. The null hypothesis of the Chi-square test of independence of respondent's region and co-management was rejected (p-value= 0.03416); therefore, it was possible to claim the association. Respondents' views on the co-management approach depended on their living place in Norway.

Then, respondents were asked whether they would participate in the voluntary removing pink salmon from Norwegian rivers. A total of 73% agreed with the initiative, including 10% of those who were willing to participate if they were paid. Approximately 19% of respondents rejected this idea, while 8% were unsure about their actions. The "Other" response option served as a platform for respondents to speak up on this question. Not only volunteers should take eradication tasks, but the state also should contribute financially to manage pink salmon. Those who participated in the voluntary activity argued that catching pink salmon in the sea would have been more effective than struggling with this species in the freshwater.

5.4 Respondents´ fishing experience, motivations, and preferences

Most respondents liked recreational salmon fishing (96%). Most prefer to catch salmonids in rivers (68%) than in fjords (32%). Usually, fishers target Atlantic salmon, brown trout, and Arctic charr. However, in 2021, they reported primarily brown trout, Atlantic salmon, and pink salmon hauls. Respondents are experienced anglers as 82% of respondents have been practising fishing for more than seventeen years. Approximately 13% of respondents have fishing experience from eleven to sixteen years, 4% reported that they were engaged in recreational fishing from five to ten years. Only 1% exercised fishing for less than four years.

In 2021, more than half of respondents (54%) went fishing more than twenty times, 19% of anglers went fishing from eleven to fifteen times, while 16% did it from six to ten times, 9% of the respondents fished less than five times, and only 2% of respondents didn't go fishing at all. Further, 41% of anglers held daily fishing licenses, and 34% had yearly licenses. In addition, 5% of respondents bought a weekly fishing license, while one-fifth of overall respondents fished in the fjords with free of charge.

Respondents were offered to consider the motives that triggered them to go fishing (Figure 3). Most respondents (69% "strongly agree" and 26% "agree") positively associated fishing with contact with nature. Not only do Norwegians perceive recreational fishing as outdoor activity (63% "strongly agree" and 31% "agree"), but they also argued that fishing was tightly connected with fun, enjoyment, and excitement related to fishing challenge (64% "strongly agree" and 29% "agree"). Additionally, Norwegian anglers were more likely to be accompanied by friends (39% "strongly agree" and 40% "agree") than by families (25% "strongly agree" and 28% "agree") on the fishing trip. Besides, there were three times more those who were fishing for consumption (34% "strongly agree" and 27% "agree) than proponents of that purpose (14% "strongly disagree" and 6% "disagree").

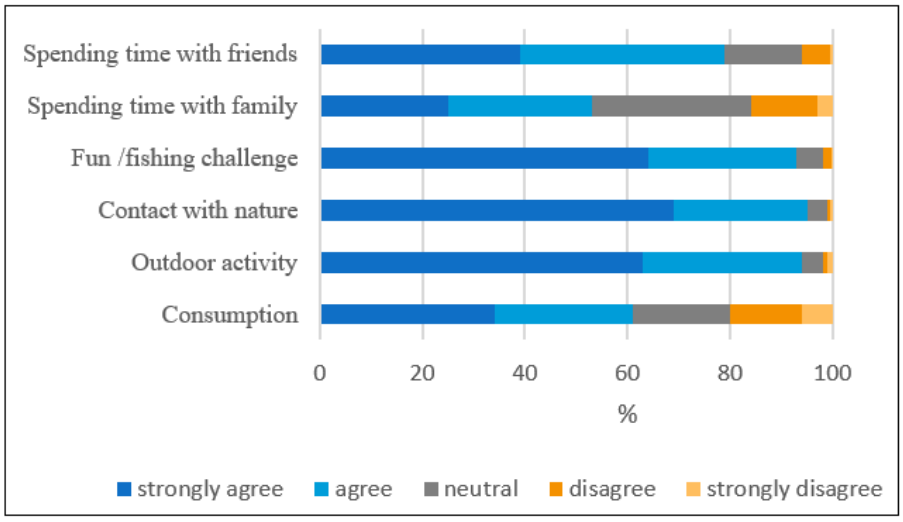

Figure 3. Angler´ motivation to go fishing

When it comes to the most critical aspects of the fishing trip, respondents distinguished *natural beauty of the fishing spot* (45% "strongly agree" and 40% "agree") and *water quality* (49% "strongly agree" and 37% "agree") as most influential factors (Figure 4). Size of the fish caught was more important for respondents (10% "strongly agree" and 42% "agree") than the number of fish caught (7% "strongly agree" and 31% "agree"). However, a rather high percentage of respondents whose attitude to the number of fish and the size of the fish caught was indifferent, 45% and 36%, respectively. Approximately 40% of respondents valued the license cost as neither significant nor irrelevant to the fishing trip. In comparison, 46% considered the license price matters (14% "strongly agree" and 32% "agree").

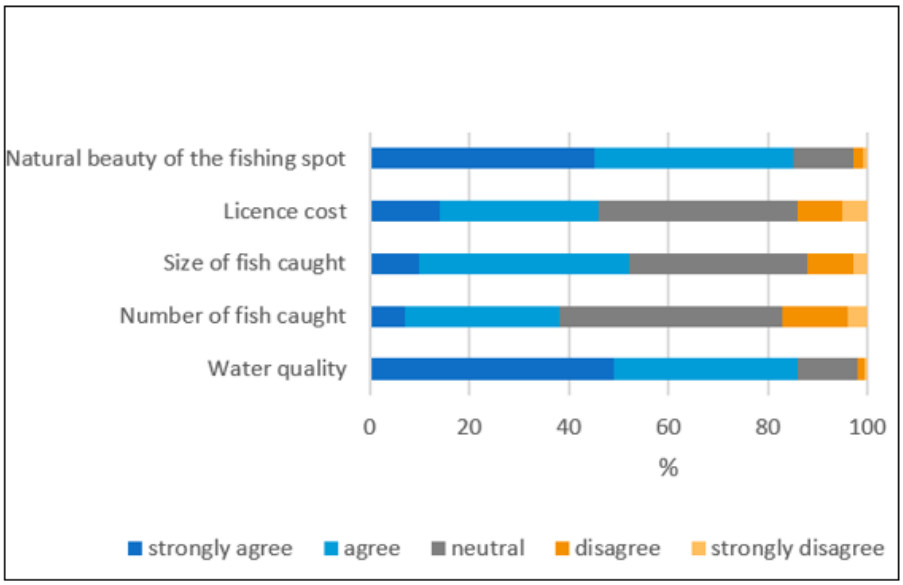

Figure 4. Aspects driving enjoyment during the fishing trip

5.5 Respondents´ willingness to pay to support eradication programme- Tobit regression results

The results showed that 67% (n = 179 out of 267) of the respondents were not willing to support the pink salmon eradication program while 33% (n = 88 out of 267) were willing to pay to fund current program, ranging from NOK500/year to NOK10000/year (Table 3). The mean of the WTP is equal to NOK607. Approximately 52% of the respondents were willing to pay NOK500 per annum, 14% selected to pay NOK1000 annually, 18% chose to contribute NOK2000 every year while 10% agreed to allocate NOK5000, but only 6% stated the maximum yearly amount equal to NOK10000. One respondent was not willing to pay due to low household income. Approximately 58% of those who were not willing to pay stated that the government should bear financial responsibility regarding pink salmon eradication. Moreover, an insignificant fraction of the respondents indicated that both river authorities, and the Norwegian Environment Agency should be in charge to tackle the pink salmon problem. While three respondents proposed increasing the fish license price to help deal with pink salmon, five people considered the pink salmon removal inefficient.

Table 3. Frequency of WTP values

WTP (in Norwegian krone)	Frequency (%)
0.00	67
500	17
1000	5
2000	6
5000	3
10000	2
Total	**100**

The Tobit model results are presented in the Table 4. The variables, *"Age", "Education", "Membership", "Experience",* and *"Resource_pest"* are negatively related to the WTP while *"Income"*, *"Solution"* and *"Co-management"* positively affect respondents' WTP. The variable *"Experience"* is statistically significant at the 10% level, and it indicates that experienced anglers have lower WTP levels for the eradication programme. When advancing one level of *"Experience"*, the WTP decreases by NOK1219.

The variables *"Solution"* and *"Co-management"* are statistically significant at the 5% level. The coefficients are positive that means, the more respondents consider the co-management proposal as a proper managerial solution and the pink salmon eradication programme as a good initiative, the more they are willing to pay. Moreover, the WTP of those who choose an additional level up in favour of the co-management approach increases by NOK660. The WTP of respondents moving across four different management regimes, starting from the "*Let them be in the rivers without doing anything*" (Table 1), increases by NOK729 when additional level up to the eradication management solution.

The estimated coefficient of *"Resource_pest"* is statistically significant at the 1% level. As expected, the respondents considering pink salmon as a resource show less WTP than those perceiving the alien fish as a pest. In monetary terms, the WTP of the proponents is decreased by NOK1769 when the pink salmon as a pest becomes a new resource.

Tobit regression method led to a better output than the Ordinary Least Squares (OLS) regression mainly due to the nature of the dependent variable WTP, which is censored and non-normally distributed. In this case, one expects the OLS method to result in biased and inconsistent estimators. The analysis of the regressions' outputs proves that Tobit regression performed better (Table 4). First, the joint significance test for Tobit (H0: all coefficients are simultaneously equal to 0) resulted in rejecting the null even at the level of 1 % (p-value = 0.00072526). For the OLS I regression run for the whole dataset, the null was rejected only at 10%. Moreover, only one regressor ("Resource_pest") was independently significant at 1%. Another OLS II regression was estimated, considering only the individuals with positive WTP, in order to eliminate possible bias caused by the censored nature of the dependent variable. For that regression, however, the null hypothesis of the joint significance test could not be rejected. At the same time, only one regressor ("Resource_pest") was independently significant at 10% only. Then, the value of the coefficients for this regressor in both OLS regressions are way different from those in Tobit regression, even though the signs of some coefficients coincide in Tobit and OLSs. In addition, the multiple R-squared is much smaller for both OLS regressions than McFadden´s R^2 in Tobit (0.06509-OLS all observations, 0.09235- OLS y>0, 0.1803938 -Tobit). Finally, the intercept in both OLS regressions is quite large, which sometimes happens when regressors are weakly associated with the dependent variable.

Table 4. Comparison of the OLS regression results and Tobit results

	OLS I (all observations, All y)	**OLS II (only y > 0)**	**Tobit**
Variable	**Coeff. (St. error)**	**Coeff. (St. error)**	**Coeff. (St. error)**
Intercept	1726.75 (1030.73)	4252.14 (2942.97)	980.9 (2744)
Age	-30.68 (180.71)	314.99 (485.85)	-431 (481.9)
Education	-218.56 (253.02)	-455.97 (730.47)	-575 (695.2)
Income	61.97 (164.84)	-316.60 (485.43)	175.8 (445.5)
Membership	-153.99 (261.63)	-254.39 (872.12)	-194 (751.4)
Experience	-123.08 (273.71)	476.71 (739.31)	-1219* (700.5)
Solution	108.69 (101.15)	-181.97 (420.69)	728.9** (334.1)

Co-management	92.10 (97.80)	-69.43 (336.45)	659.8** (302.9)
Resource_pest	-688.43***(241.95)	-1327.81* (719.93)	-1769*** (657.4)
P-value	0.05398	0.5929	0.00072526
R-value	0.06509	0.09235	0.1803938[25]

`*`significant at the 10%, ** significant at the 5%, ***significant at the 1%

All other factors such as *"Age"*, *"Education"*, *"Income"*, and *"Membership"* are statistically insignificant.

5.6 Model diagnostics and validation

In the analysis, the graphs of variance of the residuals and their distribution were plotted to assess the potential presence of heteroscedasticity and normality (checking the assumption that $\boldsymbol{\mu_i \sim N(0, \sigma^2)}$. The initial choice of potential regressors was based on the single-variable regressions outcomes (choosing the significant regressors). Afterwards, the multicollinearity, significance of variables, and economic meaning helped to find the best specification.

5.6.1 Normality check

The *residual vs. fitted plot* was created for the final Tobit model to visualize the variance of the residuals (Figure 5). The plot was used to check non-linearity, unequal error variances, and outliers. The graph informs that the larger the predicted (fitted) value of a variable, the smaller become the residuals. In addition, it was observed the decrease in the variance of the residuals along the main line due to large residuals for the bigger values of dependent variable. Such variances could be a result of the dependent variable semicontinuous nature and irregular PC values. Based on economic sense the regressors, additional insights form the respondents' answers, and the existing relevant literature the model performs well.

The *Q-Q scatterplot* was made to check the normality of residuals distribution. It was seen that the great majority of the data points strictly followed the line of normal distribution. This indicates that there are no significant arguments to reject normality (Figure 5). Therefore, the relevance of the final model was ensured by the diagnostic tools that proved its homoscedasticity and normality of residuals distribution despite the fact that the mean and

[25] For Tobit model -McFadden´s R^2

median of residuals (mean= 2881.136; median= 2843.808; s.d.= 2169.36) show the slightly enlarged residuals polarisation due to the data nature. Then, following Sale *et al*. (2009), who used the 15% threshold discussed by Mitchell and Carson (1989) to evaluate the Tobit model's credibility, I calculated the McFadden's R^2= 18%. The obtained value supports the model's relevance. The lowest AIC (1548,2) value among other models also confirms the model´s relevance. In addition, to prove the Tobit model´s appropriateness, the ordinary least square (OLS) method was employed.

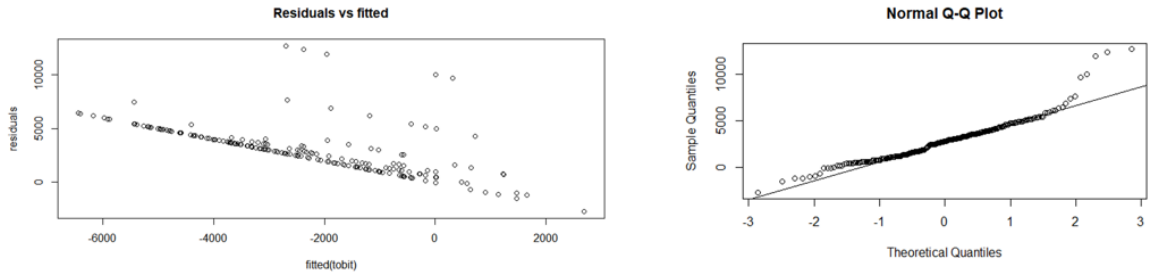

Figure 5. The left graph: actual residuals plotted against the fitted values of the dependent variable. The right graph: sample quantiles plotted against theoretical quantiles.

5.6.2 Factor correlation (multicollinearity) check

Multicollinearity is explained as the linear relationship between more than two variables (Alin, 2010). However, multicollinearity is often mixed up with the correlation that means the linear relationship between only two variables, while multicollinearity can emerge not only between two variables but also between one variable and the linear combination of many others (ibid). To conclude, the correlation is a particular variant of multicollinearity, and high correlation means multicollinearity (ibid). Therefore, it is crucial to check on multicollinearity among explanatory variables to ensure the model's precision and reliability (ibid) because multicollinearity can lead to skewed or misleading results. The non-parametric test was employed to check multicollinearity because of the nature of most variables. Therefore, Spearman's rank correlation was used in this study.

Generally, it is suspected that income and education can be somehow correlated. Moreover, it is assumed that the inclusion of income and education in the regression can lead to endogeneity issues. However, Spearman correlation coefficients did not reveal any strong associations.

Usually, *rho* -values close to – 1 or + 1 demonstrate stronger correlations than those closer to 0.

6 Discussion

This study is the first attempt to explore anglers and public perceptions on and their WTP for current pink salmon eradication management, as well as their perspectives on occurrence and potential consequences of this alien species in Norway[26].

One of the most striking findings was that most respondents were unwilling to support the eradication programme financially. At the same time, the payment card of those who expressed their willingness to financially support the eradication programme was significantly influenced by the perception of pink salmon as a resource or pest, type of management solution scenario, co-management as an approach to deal with pink salmon and the level of their fishing experience and their less related social-demographic characteristics, such as age, income, education, and membership. The arrival of the pink salmon could generate environmental problems, including competing for food and resources, spreading diseases to other species, and gradually becoming a dominant species. Invasive species like pink salmon were considered the second most threatening factor to native salmonids after aquaculture.

6.1 Public´s acceptance of the current eradication programme and their WTP for it

6.1.1 Public´s acceptance of the current management programs

The revealed differences in supporting the current programme can be due to respondents' perceptions of resource management responsibility, potential establishment of pink salmon in rivers, scientific information availability on pink salmon, and unstudied potential threats to native salmonids.

The primary reason that most respondents were unwilling to pay was that they thought the state should bear all financial responsibility in terms of this programme. Natural resources and the state of their environmental quality, in general, are public goods and belong to and are governed by the nation (Theeuwes, 1991). Furthermore, the fish and freshwater resources are common-

[26] The preliminary results of the study were presented at the International Seminar on Pink Salmon in the Barents Region and Northern Europe in 27-28 October 2021 in NIBIO Svanhovd.

pool, non-excludable resources for all the users (Perman *et al.*, 2011). Thus, it is believed that the Norwegian government should financially take primary responsibility for managing the pink salmon problem as respondents suggested that high national taxes and costly fishing licenses should cover the cost of the pink salmon eradication program. As resource users, anglers are responsible for protecting and sustainable resource use. However, the results revealed that the Norwegian government cannot rely too much on Norwegian anglers to solve the pink salmon problem through economic instruments but by cooperating with anglers and local fishing organizations.

Secondly, respondents also explain their unwillingness to pay for eradication because of scarce scientific information on pink salmon, which is a significant obstacle to define the proper management measure. Probably the "wait and see" approach (Epanchin-Niell, 2017) employed in Norway before 2017, followed by the drastic change of management development immediately to costly eradication, has been slightly overwhelming for anglers to decide whether the eradication measure is effective and based on scientific evidence. Interestingly, some of the respondents elicited their WTP as equal to the status quo because they were sceptical about whether the eradication programme was an effective measure to deal with pink salmon "*Det er en håpløs kamp å utrydde den*[27]". Probably this is because many anglers have observed the pink salmon in rivers for a long time and many of them are aware about its high fecundity and abundance. Moreover, according to Hesthagen and Sandlund (2007), and VKM (2020), pink salmon has already been established[28] in some rivers in the eastern Finnmark and is highly likely to extend the area of natural propagation in Norwegian watercourses. Therefore, the tipping point in terms of the pink salmon establishment had already passed in some water bodies. Considering most respondents are experienced and highly educated anglers, they probably believe that the costly eradication measures would not work as the government intended. Moreover, according to the Nature Diversity Act, the most radical measure should be implemented "*when the purpose cannot be achieved in any other satisfactory manner"*[29]. Probably, the majority of respondents could not find enough information justifying the costly

[27] In English: "It is hopeless to eradicate it (pink salmon)".

[28] According to Kocovsky et al. (2018), there are many definitions of terminology "established" invasive species. In this study, established non-native species means self-reproducing in local ecosystem species.

[29] https://www.regjeringen.no/en/dokumenter/nature-diversity-act/id570549/ (accessed 16.04.2022)

labour-demanding eradication measure and refuse to support the current management programme.

The low level of knowledge on pink salmon and a lack of a scientifically proven management strategy can also be a result that only 33% of respondents hypothetically agreed to financially (average WTP=NOK607) support the eradication program annually. *"Som bedrift vil jeg gjerne bidra også økonomisk, men er avhengig av om vi tro på tiltaket*[30]*»*. This and many other similar respondents' opinions should be an alarm bell regarding the appropriateness of the current eradication management programme and future management development. Generally, people are likely to act relying on the available information they possess, including that linked to the invasive species; moreover, the more they are aware of it, the more likely they have a higher WTP (Nakano *et al*., 2016; Levers & Pradhananga, 2021). In other words, "*Proper action is knowledgeable action*" and "*Proper knowledge is actable knowledge*" (Goldkuhl, 2004).

Lastly, as an alien species, pink salmon has not been considered the most threatening factor affecting native salmonids. Aquaculture has still been considered the factor that affects the wild salmon population the most. The long-standing conflict between recreational fisheries and the aquaculture industry (Liu *et al*., 2019) is probably tightly linked to the scientific discoveries that the finfish farmed industry causes the most deleterious impact on native salmon stocks (VRL 2018, 2021). Moreover, economic losses in the recreational salmonid fishing industry have been observed before the pink salmon influx in Norway. For example, the imposed fishing restrictions to restore wild salmon stocks have been implemented to mitigate the management and scientific omission costing local salmonids the massive die-offs and those measures have significantly decreased the angler's satisfaction (Stensland *et al.,* 2021). Therefore, anglers probably refused to support the current eradication programme because of the mismatch between the existing main culprits for the wild salmon stocks and implemented costly eradication measures against pink salmon.

6.1.2. Determinants of WTP

The four sociodemographic determinants used for the Tobit model were not statistically significant with the WTP. However, *"Age"*, *"Education"*, and *"Membership"* are negatively related to the WTP, while *"Income"* is positively associated with the WTP (Table 4). Another

[30] In English: "As a company, I would also like to contribute financially, but depend on whether we believe in the measure".

sociodemographic character was gender. In this study, only 6% of respondents are women. If more women participated in the survey, the gender might have an influence on the WTP because women have significantly higher WTP in general (Toivonen *et al.,* 2004; Levers & Pradhananga, 2021) and demonstrate different attitudes towards specific environmental management options, such as eradication (Bremner & Park, 2007) that can impact the WTP choice.

The *"Experience"* as the WTP determinant was statistically significant and negatively associated with the WTP. The results showed that the middle-aged, highly educated, and experienced anglers gave a lower WTP for the eradication programme than those who are younger, low educated and less experienced anglers. This might indicate that better-educated and experienced anglers have better knowledge and understanding of the pink salmon issue and perceived eradication as not a proper long-term measure against pink salmon arrival. Indeed, Edwards *et al*. (2016) argue that high-educated people are more aware and engaged in discussing environmental problems. Additionally, the experienced anglers have probably long observed the pink salmon development dynamics and possess more ecological knowledge of this non-native fish, convincing them that the eradication program was not the right measure to deal with the arrival of pink salmon "*Håper forskerne begynner å høre på oss som bruker elvene og har gjort det i 40 år*[31]*".* As expected, respondents with higher levels of income had a higher WTP.

Next, respondents holding membership in environmental, fishing and hunting organizations had lower WTP than those who did not have a membership in professional organizations. This contradicts an earlier study where respondents holding conservation organizations membership were more likely to support control programmes (Bremner & Park, 2007). It is probably linked to the common opinion that the government should care about public goods such as marine resources.

Respondents who perceived pink salmon as a resource were associated with a lower WTP than those who considered pink salmon as a problem (*"Resource_pest")*. This is expected because those respondents who revealed lower WTP recognized pink salmon´s great potential as a

[31] In English: "Hope the researchers start listening to us who have been using rivers for 40 years".

resource for commercial sea fishing that aligns with the recent conclusion of Nofima that "*Pink salmon is definitely suitable for human consumption*". They also considered pink salmon as a suitable fish for recreational fishing, especially these days when some salmon rivers are closed due to depleted wild salmon stocks (Stensland *et al*., 2021) and both landowners and anglers are unsatisfied with the current wild salmon situation. Meanwhile, those respondents who accepted the eradication measure had a higher WTP. It aligns with existing studies showing that people who consider environmental protection measures effective and feasible tend to demonstrate higher WTP (Nishizawa *et al.*, 2006; Han *et al*., 2011; Chen *et al.,* 2018).

Respondents' high confidence level in and acceptance of the co-management (*"Co-management")* approach was associated with the higher WTP for the eradication programme among Norwegian anglers. These results align with studies demonstrating that local communities' involvement in decision-making positively affects their acceptance of the environmental programs; besides, those engaged in the participatory activities have a higher WTP (Bremner & Park, 2007; Nakano *et al*., 2016; Chen *et al*., 2018). Probably among those anglers with higher WTP many lived in Northern Norway. As stated before, the influx of pink salmon was reported primarily in Northern Norway, so those living in Troms and Finnmark counties are likely to be more interested in a co-management approach to solving this problem effectively and efficiently, so probably they had a higher WTP. The probable explanation for lower WTP could be the sceptical attitude towards the current local fishing organizations, as some respondents consider them to have vested interests in getting state financial aid. Some respondents also believed the local fishing and environmental organizations were not professional enough to solely cope with pink salmon and demonstrated lower WTP than those who considered co-management a decent and relevant idea *"Miljøforvaltningen må styre dette, men samarbeid med andre om praktiske tiltak for å kunne sette inn størst mulig innsats for å begrense forekomsten i størst mulig grad»*[32].

The final determinant of the WTP relates to the anglers' choice of the management measures for pink salmon (*"Solution").* Four management scenarios demonstrate different levels of WTP; the lowest WTP was observed among those respondents who considered not intervening in the pink salmon issue, as they perceive fish migration as natural self-regulating process. However,

[32] In English: "The environmental administration must manage this, but cooperation with others on practical measures is important in order to be able to make the greatest possible effort to limit the occurrence as much as possible".

those who considered the management scenarios advocating pink salmon fishing in the sea and proper management measures implemented for the pink salmon to coexist in rivers demonstrated higher levels of WTP. In addition, several anglers notified that the pink salmon case bears similarities to King crab occurrence in Norwegian waters (*Paralithodes camtschaticus*). Both species are the outcomes of introduction programs in Russia, are of high commercial value, and attract scientific and management attention owing to their diverse socio-ecological and economic impacts. However, despite intense stakeholders´ clashes and ecologists´ warnings, the King crab industry has become lucrative in terms of catches and income[33], especially for fishers living in Northern Norway. King crab set new export records in 2021[34] alongside being perceived as species with the highest ecological and invasion potentials (Sandvik *et al*., 2020), then probably not all alien species are harmful and should be eradicated. Instead, the proper management measures are feasible, and those respondents who consider them better than eradication measures have much lower WTP.

6.2 Public´s state and source of current pink salmon knowledge amongst fishers and the general public

Most of the respondents associated pink salmon occurrence in Norwegian rivers with anthropogenic activity, mainly with the acclimatization program in the neighbour country. In the Soviet Union, pink salmon was selected as species for the introduction programme particularly because of the short freshwater life stage, the low level of feed consumption during seaward migration, and fast maturation rate (Zubchenko *et al*., 1998, Dorofeeva *et al*., 2006). Following some respondents and Hesthagen and Sandlund (2007), Norwegian anglers have been accustomed to pink salmon since the 1960s, particularly in the Norwegian northern watercourses. However, a fraction of respondents assumed that poor national fisheries management has caused the pink salmon arrival in Norway. Probably, those anglers who have caught pink salmon for a long time expected its assimilation in the Norwegian ecosystems and believe that not enough management activity has been used to prevent it, as some pink salmon returns have been repeatedly observed in the Finnmark (Sandlund *et al*., 2019). Respondents also explained pink salmon occurrence in Norway to climatic shifts and natural regulation. According to some anglers, poor nutrition and the warming ocean triggered pink salmon to expand habitat areas. Indeed, pink salmon is characterized by high ecological plasticity and

[33] https://en.seafood.no/news-and-media/news-archive/record-high-norwegian-seafood-exports-in-2021/ (accessed 11.04.2022)
[34] https://en.seafood.no/news-and-media/news-archive/record-high-norwegian-seafood-exports-in-2021/ (accessed 11.04.2022)

quickly responds to environmental changes (Shuntov *et al*., 2017; Kirillova *et al*., 2018) compared to local Atlantic salmon (Thorstad *et al*., 2021).

A further conspicuous finding was respondents´ strong opinions that the largest threat to local salmonids comes from aquaculture. Escaped farm fish, salmon lice, infections related to fish farming are "*expanding population threats"* that can lead to the terminal wild salmon population stage (VRL 2018, 2021). Invasive species, particularly pink salmon, was ranked by respondents as the second greatest threat to local salmonids. Overfishing was ranked as the third threat to native salmonids. The considerable overexploitation of the wild salmon population, for example, in the Tana River unfortunately triggers less scientific and management attention (Forseth *et al*., 2017) than the pink salmon invasion.

It was also revealed that for a considerable proportion of respondents, scientific information was required to assess the potential effects of pink salmon on native salmonids (VRL 2018, 2021) and decide whether pink salmon can coexist in Norwegian ecosystems. According to respondents, competing for food and habitat with native salmonids as well as spreading diseases are the most possible adverse consequences of pink salmon existence in Norway. The high level of uncertainty among the respondents is probably associated with the varying current scientific opinions regarding pink salmon's co-existence with local salmonids. For example, Jonsson and Jonsson (2018) argue that there is no knowledge of the significant competition for food in rivers between pinks and native salmonids because little is studied about the timing of seaward migration of pink salmon smolt. In contrast, Sandlund *et al*. (2019) and Dahl (2020), referring to the VKM, impart that pink salmon and local salmonids can compete for food in freshwater and spawning grounds. According to Bjerknes and Vaag (1980), the presence of diseases was not found in pink salmon stocks in Northern Norway. Mo *et al*. (2019), Sandlund *et al*. (2019) state that the only research on pink salmon diseases was conducted in rivers of Northern Norway, Tana and Neiden, which did not detect any of the explored viruses. However, according to Sandlund *et al*. (2019) and VKM conclusions, there is a potential threat to native salmon populations if pink salmon exist in significant numbers in Norwegian rivers.

Despite the high level of uncertainty and concern towards pink salmon among anglers, surprisingly, an approximately equal number of respondents agree and disagree that pink salmon co-existence in Norwegian rivers is possible. Most of those who consider pink salmon co-existence feasible argued that the proper management control is essential and scientific

information was required to assess the potential effects of pink salmon on native salmonids (VRL 2018, 2021) and define the proper management measures.

With regards to information sources on pink salmon, the results show that respondents obtained information mainly from the scientific literature. It is logical as most respondents are highly educated and are involved in science. People also trust social media, TV, newspapers when searching for information on pink salmon that also corresponds to the results of the national survey "Norsk mediabarometer 2020". However, messages coming from the respondents such as "*Jeg har vært i kontakt med forskere som har vært sitert i media som tegner et helt annet bilde enn det media gjør*[35]*»* and *"Jeg er redd den kan bli et alibi for oppdretsnæringa til å forklare nedgang i laksebestanden*[36]*»* provide indications that the media propaganda are agitating for pink salmon eradication by sensationalizing this issue that probably serves well only for certain stakeholders.

Results prove that there is an increasing interest in the pink salmon case and anglers' demand a full inquiry into the pink salmon handling of existence. Respondents initiated conversations with freshwater scientists and talked to local fisheries authorities. They also approached NJFF, NINA, ninord.no, lakseelver.no for information on pink salmon. Some respondents also suggest that international cooperation can be employed to cope with pink salmon arrival. The latest news from the Russian scientists[37], who have become closer to shedding light on the pink salmon sea phase behaviour affecting the returns quantity, is probably a proper motive to facilitate international research cooperation.

6.3 Public´s potential social and economic perspective of pink salmon

There is no apparent gap between public perceptions of pink salmon as a resource or a pest. However, more people consider pink salmon a new food resource and a proper species for recreational salmonid fishing. When Norwegian anglers discussed the pink salmon's potential for consumption, they referred to Russian long-standing successful experience with this

[35] In English: "I have been in contact with researchers who have been quoted in the media who said completely different things than what media does".

[36] In English: "I am afraid it could be an alibi for the aquaculture industry to explain the decline in the salmon stock".

[37] The pink salmon sea phase is also called "Black hole" due to a lack of scientific data. https://vestiprim.ru/news/ptrnews/121439-uchenye-vniro-izuchili-chernuju-dyru-novye-dannye-o-lososjah-perevernut-nauku.html (accessed 10.04.2022)

biological resource. This species has become a significant source of income for the neighbouring national and local economy (Shuntov *et al*., 2019) as well as an essential source of protein, fatty acids, and balanced mineral composition in the populations diet (Ryzhkova & Kruchinina, 2020). Considering the prevalence of the utilitarian fishing approach has been a common trait among Norwegian anglers (Aas & Kaltenborn, 1995; Liu *et al*., 2019), pink salmon has potential to become an established fishery in Norway if pink salmon is caught in the sea as proposed by many of the respondents *"Fisker i sjøen. Stor etterspørsel*[38] *"*. Respondents also warned that pink salmon was not edible if caught in the river as fish returned to freshwater to spawn and were physiologically preparing to die after that. Furthermore, pink salmon is the least susceptible salmonids to the sea lice[39], one of the most adverse current threats to local salmonids (VRL 2021). Such a biological advantage could be a potential for pink salmon to be employed as a resource in Norwegian fisheries and partly substitute national economic losses due to wild Atlantic salmon depleting stocks and expanding aquaculture activity.

Not only there are diverse opinions regarding pink salmon´s potential as a food resource, but there are also different opinions concerning pink salmon utilisation in recreational fishing as has previously occurred with Chinook salmon (*Oncorhynchus tshawytscha)* in Chile (Cid-Aguayo *et al.*, 2021). Probably those consumption-oriented anglers or those who highly value the fish size do not see any positive perspective for pink salmon to coexist in Norwegian rivers. However, a less consumption-oriented approach has also been observed among the younger generation of Norwegian freshwater anglers (Stensland *et al.*, 2021). Besides, probably also those in this survey who consider the number of fish caught as the valuable aspect of the fishing trip (Moeller &Engelken, 1972) may benefit from pink salmon existence in Norway.

However, most anglers´ concern for pink salmon becoming a recreational resource in Norway is its unstudied possible detrimental effects on native ecosystems, including pink salmon carcasses. While some respondents argue that *"Pukkellaks er en ressurs også for locale arter"*[40] can enrich the low-nutrient Norwegian ecosystems with extra energy (Mo *et al*., 2019), other respondents consider pink salmon carcasses pose a risk to local ecosystems. Even though the

[38] In English: "Fish in the sea. High demand".
[39] https://www.fishfarmingexpert.com/article/susceptibility-to-sea-lice-involves-responses-by-both-the-parasite-and-the-host/ (accessed 11.04.2022)
[40] In English:" Pink salmon is a resource also for local species".

information provided by the scientists researching the river Vesterelva (Finnmark) shows that pink salmon carcasses can serve as a potential food source for local wildlife, more research is required (Dunlop *et al*., 2021b). And this is true because there is the risk of losing the most significant share of anglers who rank the beauty of the spot and water quality as the most critical aspects of the fishing trip. Furthermore, fish carcasses can contaminate water and induce eutrophication in rivers (Alekseev *et al*., 2019) as well as emit an odour that could deter anglers.

6.4 Policy and management implications

The information gained about the pink salmon eradication program derived from the public's perceptions and their WTP can serve as a social marker that indicates which type of future programs or policies can be accepted amongst Norwegian anglers and locals during continued pink salmon runs, and also design an effective strategy for ensuring the further program's financial sustainability.

The current public opinions regarding pink salmon management are that direct state funding is the most appropriate way to fund local fisheries organizations and landowners to carry out eradication methods. In addition, it would be an advantageous to continue engaging local fisheries organizations and local representatives to find solutions collectively on how to deal with pink salmon. This way the government bodies and fishers could share responsibility for the defined management measures (Jentoft, 1989). Norwegian government agencies have all incentives to employ this management method, as the Norwegian anglers demonstrate a high level of fishing experience and motivation to solve the pink salmon problem in the most sustainable way.

Therefore, even if the implementation of the co-management process can be a demanding administrative and execution process it appears that it is likely to receive support through the involvement of many Norwegian anglers ready to volunteer time to remove pink salmon during the coming fishing seasons. However, more people can be motivated to participate in this procedure if they are paid. It is crucial for national and local authorities not to completely rely on the public's high motivation, as many respondents do not accept any public's engagement in the pink salmon solving process. Even though the co-management approach could be implemented to tackle the pink salmon problem, financial transparency and scientific proof of actions committed by the fishing and environmental organizations are required.

Another aspect of engaging anglers is to motivate and invite them for participating scientific research. A positive experience with anglers engaging in counting pink salmon entering the rivers in 2017 can be an incentive to initiate more similar activities to engage Norwegian anglers who are experienced and motivated to monitor the morpho-biological, quantitative, and spatial indicators of pink salmon populations. Considering the rapid climatic changes in the Arctic, it is crucial not only to track the dispersal of existing pink salmon populations, but to immediately react to their expansion as well as monitoring and detect possible new species arrivals (Hesthagen & Sandlund, 2007). The Norwegian anglers can probably significantly contribute to these essential management activities as well as such state-science-public cooperation is not costly but develops a good rapport between the public and authorities.

Research revealed that there is a high level of pink salmon awareness and fishing experience among respondents, many of which are working in science and natural resource management and are interested in the scientifically proven management measures. Therefore, the government should focus on improving the scientific data on pink salmon to provide anglers with reliable information to justify implementation of the management measures, as well as to obtain public´s trust and support. Many knowledge gaps concerning pink salmon ecological effects exist which generates uncertainty and can lead to ineffective and inefficient management measures. Holistic scientific research, including international collaboration, on pink salmon, focusing on the ecological interaction of this species with local salmonids is required.

When it comes to assimilation of scientifically proven information on pink salmon, it is essential to ensure that it reaches the public. Such media channels as social media, TV, and newspapers coupled with the scientific literature can assist in information assimilation. Still, stringent management measures are required to avoid information mismanagement failure that engenders social clashes.

Study results can also help develop policies related to the pink salmon that address public and angler concerns and suggestions. The perception of pink salmon as a resource can accelerate the development and implementation of certain management measures that can help with a reduction if pink salmon numbers. *"Pukkellaks kan være bade ressurs og problem, avhengig*

av hvilket perspektiv du betrakter arten i[41]*»*. Following the common opinion of respondents that pink salmon is a resource that should be fished in the sea, fisheries management together with the relevant scientific organizations should examine how pink salmon can be harvested to avoid the by-catch of local salmonids and ensure the high quality of caught fish. Preliminary works toward a pink salmon quota for local commercial fishers could be initiated as the demand for pink salmon has been registered in this study. The pink salmon acceptance also as a recreational species could be profitable for the management, landowners, and anglers. For instance, reduced licence costs in the lower river reaches could attract anglers and increase their significantly decreased satisfaction due to some salmon rivers being closed (Stensland *et al.*, 2021). Such fishing regulations can also financially support landowners suffering from the currently imposed restrictions and significantly contribute to the mitigation of pink salmon arrival. Overall, our results indicate where pink salmon could be accepted as a new resource to generate employment and contribute to the local economy as well as supply society with good nutrition if appropriate management choices and courses of action are made.

6.5 Limitations of the study

Generally, questionnaire-based study can have certain limitations with respect to the sample representativeness (Bremner & Park, 2007). A simple random sampling design was used in this study to ensure the generalizability of findings and avoid sampling bias. Still, some bias can exist due to undercoverage bias. Unfortunately, due to time and financial constrains this thesis work was impossible to include responses from foreign tourists who comprised a share of freshwater anglers in Norway during the salmonid fishing season. Therefore, it suggests that future research should include foreign tourists' perceptions of pink salmon by employing stratified random sampling if possible. However, this work's sampling strategy and findings are consistent with the previously conducted research (Liu *et al*., 2019). There can also be self-selection bias among the respondents in that the questionnaire was distributed assuming that people who are registered in or linked to related organizations are more likely to answer than those who are outside the circles, especially when it comes to mail surveys (Bremner & Park, 2007; Navrud, 2008).

[41] In English: “Pink salmon can be both a resource and a problem depending on one´s perspective of this species”.

Although CVM is the most employed approach to reveal non-use values, the study results can be sensitive to the existence of outliers (Navrud, 2008). The normality of residuals distribution in this study could probably have been improved if the questionnaire had had more choices for the payment card, including the higher value of the highest current offer. Next, the selection of variables based on the existing literature and the researcher's problem perception could also affect the normality of residuals and the presence of heteroscedasticity. Then, as some variables had the "Other" option, the interpretation and coding of those responses could have been assumed as subjective and influencing the study results. However, manipulation with coding was essential to define the best fitted model identified by AIC, McFadden's R, joint significance test. Overall, possible biases did not affect the reliability of the study results.

7 Conclusion

This study's results are consistent with the contemporary social perceptions of pink salmon arrival as a significant issue without an unambiguous public attitude and a straightforward solution. However, the first attempt to explore Norwegian anglers' perceptions of pink salmon current management measures contributes to consolidating several profound insights that can be employed to tailor the policy and manage pink salmon sustainably.

Results demonstrated a high level of public awareness of pink salmon among anglers, coupled with their deep understanding of the proper management approaches and a broader view of the socioeconomic perspective of this species in Norway. The golden thread running through this study is that pink salmon can be perceived as a new resource providing local communities with employment, income, and food. Still, it can also be an arduous hurdle if proper catch methods and policies are not implemented.

Together the study results revealed that it is time to empower and support local fishing organizations to manage pink salmon. It is also crucial to facilitate scientific research, including international collaboration, on pink salmon, focusing on the ecological interaction of this species with local salmonids as a lack of reliable scientific information generates uncertainty, leading to ineffective and inefficient management strategy and expenditure of taxpayers' money. Overall, engagement of all relevant stakeholders in ISM is the cornerstone for further actions if the rapid eradication of pink salmon in Norway fails. Besides, the inclusion of a social-economic dimension into the decision-making builds a good rapport between the

management bodies and the public that produce trust and confidence in environmental programmes and better compliance with management measures.

Finally, this study has opened the door to future research on pink salmon among different stakeholder groups, including based on their geographical place of residence, which has great potential to contribute to successful and sustainable ISM in Norway. In addition, it has provided a basis for further study on assessing management strategies and policy in terms of emerging issues such as pink salmon arrival.

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Appendix

Appendix 1 – Questionnaire in Norwegian

Det samfunnsøkonomiske perspektivet på pukkellaks i Norge

Kjære respondent,

Jeg er Ekaterina Aasmaa, masterstudent ved Norges fiskeriskole ved UiT Norges arktiske universitet. Som en del av masteroppgaven min inviteres du til å delta i en forskningsstudie som undersøker det sosiale og økonomiske perspektivet på pukkellaksens tilværelse i Norge. Vi ber deg dele din oppfatning av konsekvensene av pukkellaksens ankomst i norske elver, og din mening om fiskeriforvaltningstiltak knyttet til pukkellaks. Fangsten av pukkellaks har økt betydelig den siste tiden i Norge, og det er funnet pukkellaks i flere norske elver. Det er imidlertid ingen klar forståelse for denne fremmede arten i det norske samfunnet, og spørsmålet om pukkellaksen er en ny ressurs eller et problem er fortsatt åpent.

Spørreskjemaet innholder 32 spørsmål og tar opptil 10 minutter. Det finnes ingen riktige eller gale svar, men din ærlige mening vil være svært viktig og verdifull for å hjelpe oss med å bedre forstå konsekvensenene og perspektivene med hensyn på pukkellaksens tilværelse i norske elver. Det vil også hjelpe oss med fremtidige forskningsprioriteringer og forvaltningstiltak for håndering av pukkellaks i norske elver. All informasjon du gir oss vil bli holdt strengt konfidensielt, og analysene og resultatene vil være anonyme. Vi vil presentere forskningen og resultatene på vitenskapelige konferanser og møter.

Vi vil være takknemlige for å motta svarene dine! Takk!

Ta gjerne kontakt med meg med spørsmål, min kontaktinformasjon: epost: eaa046@uit.no, tlf: +47 91910530, eller min veileder førsteamanuensis Yajie Liu epost: yajie.liu@uit.no, tlf: +47 99345066

1. Har du noen gang fanget pukkellaks? *

- Ja
- Nei

2. Liker du å spise pukkellaks? *

- Ja, liker det veldig godt
- Ja, det er ok, ikke noe spesielt
- Nei, liker det ikke i det hele tatt
- Jeg vet ikke

3. Når du fisker i elvene, har du noe imot å fange pukkellaks i stedet for andre laksetyper, som atlantisk laks, ørret, røye? *

- Ja, misliker dem
- Nei, men foretrekker andre laksearter
- Nei, foretrekker pukkellaks fordi fangst og konsum av pukkellaks gir mulighet til å redusere beskatningen av naturlige arter
- Vet ikke

4. Etter din oppfatning, hva er hovedårsaken til at pukkellaks kommer til norske farvann? (flervalg) *

- [ ] Klimaendring
- [ ] Historiske og nåtidige menneskelige aktiviteter
- [ ] Dårlig fiskeriforvaltning
- [ ] Bevisst introdusert
- [ ] Annet

5. Med tanke på din nåværende kunnskap om pukkellaks, tror du at *

- ( ) Sameksistens av pukkellaks og norsk biologisk mangfold er mulig
- ( ) Sameksistens av pukkellaks og norsk biologisk mangfold er umulig
- ( ) Sameksistens av pukkellaks og norsk biologisk mangfold er mulig under forsvarlig fiskeriforvaltning
- ( ) Det er behov for mer vitenskapelig informasjon for å bestemme
- ( ) Annet

6. Hva er din foretrukne informasjonskilde om pukkellaks? (flervalg) *

- [ ] Bøker
- [ ] Magasiner
- [ ] Vitenskapelig litteratur
- [ ] TV
- [ ] Radio
- [ ] Sosiale medier
- [ ] Regjering
- [ ] Venner og familie
- [ ] Annet

7. Er du enig i at det er mangel på vitenskapelig informasjon om pukkellaks blant etater og samfunn i Norge? *

- ○ Ja, det finnes ingen vitenskapelig informasjon om pukkellaks
- ○ Ja, det er knapp informasjon om pukkellaks
- ○ Nei, det er informasjon om pukkellaks
- ○ Nei, det er mye vitenskapelig informasjon om pukkellaks
- ○ Jeg vet ikke

8. Hva er den største trusselen mot de naturlige fiskeartene, spesielt laksefisk, i norske elver? Merk hvor mye du enig eller uenig i hver uttalelse *

	Helt enig	Enig	Nøytral	Uenig	Helt uenig
Klimaendring	○	○	○	○	○
Akvakultur	○	○	○	○	○
Invaderende arter (f. eks. pukkellaks)	○	○	○	○	○
Marine aktiviteter (f.eks. skipstraffikk, industriell aktivitet)	○	○	○	○	○
Overfiske	○	○	○	○	○
Ingen fare	○	○	○	○	○

9. Tror du pukkellaks er en ny ressurs som kan brukes, eller et problem? (velg alle mulige varianter) *

- ☐ Ja, det er en ressurs som vil forbedre laksebestanden for fritidsfiske
- ☐ Ja, det er en ressurs som kan konsumeres som matfisk
- ☐ Nei, det er problem, da det er en invaderende art
- ☐ Annet

10. Under er noen økologiske og miljømessige problemer som sannsynligvis kan oppstå på grunn av pukkellaksens ankomst. Merk hvor mye du er enig eller uenig i hver uttalelse. *

	Helt enig	Enig	Nøytral	Uenig	Helt uenig
Formering med naturlige arter, nedgradering av genforrådet til naturlige laksefiskarter	○	○	○	○	○
Konkurranse om mat og ressurser med naturlige arter	○	○	○	○	○
Spredning av sykdommer til andre arter	○	○	○	○	○
Tap av biologisk mangfold	○	○	○	○	○
Gradvis erstatte andre arter og bli den dominerende arten i økosystemet	○	○	○	○	○
Ingen problemer	○	○	○	○	○

11. Hva vil du at forvaltningen skal gjøre med pukkellaks? *

- ○ Fjern dem helt fra elvene
- ○ Iverksette tiltak slik at de kan eksistere sammen med andre fiskearter i elvenes økosystemer
- ○ La dem være i elevene uten å gjøre noe
- ○ Jeg vet ikke
- ○ Annet

12. Er du enig i at det å involvere fiskerimiljøer og lokalbefolkning i beslutninger og planlegging er avgjørende for tilstrekkelig fiskeriforvaltning når det gjelder pukkellaksens tilværelse i elver? *

- ○ Ja, jeg liker veldig godt ideen om å igangsette en slik samarbeidende forvaltning (co-management)
- ○ Kanskje det kan være et alternativ
- ○ Nei, jeg tror ikke det kan fungere
- ○ Nei, liker ikke denne ideen i det hele tatt fordi det gjør situasjonen verre
- ○ Jeg vet ikke
- ○ Annet

13. Vennligst beskriv effekten på din fiskeopplevelse av tilstedeværelsen av pukkellaksen i norske elver . *

- ( ) Jeg liker det veldig godt fordi det er mer fisk å fange
- ( ) Jeg liker å fiske for å oppleve naturen, derfor har jeg ingen preferanser om hvilken type fisk som finnes i elver
- ( ) Jeg liker ikke å fiske fordi den fremmede arten (pukkellaks) eksisterer i elver
- ( ) Jeg vil ikke fiske så lenge pukkellaks eksisterer i elver
- ( ) Ingen effekter
- ( ) Annet

14. Vil du delta i frivillig aktivitet for å fjerne pukkellaks fra elver? *

- ( ) Ja, jeg vil delta i denne aktiviteten
- ( ) Ja, jeg vil delta i denne aktiviteten under forutsetning av at den er betalt
- ( ) Nei, jeg vil ikke delta i denne aktiviteten
- ( ) Jeg vet ikke
- ( ) Annet

15. Vil du være villig til å bidra økonomisk til utryddelsen av pukkellaks? *

- ( ) Ja, 10000kr/år
- ( ) Ja, 5000kr/år
- ( ) Ja, 2000kr/år
- ( ) Ja, 1000kr/år
- ( ) Ja, 500kr/ år
- ( ) Nei
- ( ) Annet

16. Liker du å fiske laksefisk for rekreasjon? *

- ( ) Ja
- ( ) Nei

17. Hvilke arter av laksefisk retter du deg mot? (velg alle mulige varianter) *

- [ ] Atlantisk laks
- [ ] Pukkellaks
- [ ] Ørret
- [ ] Røye
- [ ] Alle av dem
- [ ] Annet

18. Hvilke laksearter fanget du mest av i løpet av 2021? (velg alle mulige varianter) *

- [ ] Atlantisk laks
- [ ] Pukkellaks
- [ ] Ørret
- [ ] Røye
- [ ] Annet

19. Hvor foretrekker du å drive laksefiske? *

- i fjorder
- i elver/innsjøer
- Jeg har ingen preferanse

20. Hvor mange år med fiskeerfaring har du? *

- Ingen
- 1-4
- 5-10
- 11-16
- 17 eller mer

21. Hvor mange fiskedager (turer) har du hatt i 2021? *

- Ingen
- 5 eller mindre
- 6-10
- 11-15
- 20 eller mer

22. Fisker du for (vennligst merk hvor mye du er enig eller uenig med hver uttalelse) *

	Helt enig	Enig	Nøytral	Uenig	Helt uenig
Eget konsum	○	○	○	○	○
Utendørs aktivitet	○	○	○	○	○
Kontakt med naturen	○	○	○	○	○
Gøy / fiskeutfordring	○	○	○	○	○
Tilbringe tid med familien	○	○	○	○	○
Tilbringe tid med venner	○	○	○	○	○

23. Hvilke aspekter er viktige for deg på fisketuren? Merk hvor mye du er enig i eller uenig i hver uttalelse. *

	Helt enig	Enig	Nøytral	Uenig	Helt uenig
Vannkvalitet	○	○	○	○	○
Antall fisk fanget	○	○	○	○	○
Størrelse på fisk fanget	○	○	○	○	○
Kostnad på fiskekort	○	○	○	○	○
Vakre omgivelser på fiskeplassen	○	○	○	○	○

24. Hva slags fiskekort kjøpte du i fjor? (velg alle mulige varianter) *

- ☐ Døgnkort
- ☐ Ukeskort
- ☐ Årskort
- ☐ Individuell avgift
- ☐ Familieavgift
- ☐ Annet

25. Hvor gammel er du? *

- ○ under 18 år
- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-67
- ○ 68 eller eldre

26. Hvilket kjønn er du? *

- ○ Mann
- ○ Kvinne
- ○ Foretrekker ikke å svare

27. Hva er husholdningens omtrentlige gjennomsnittlige bruttoinntekt? *

- ○ under 500000kr
- ○ 500000-750000kr
- ○ 750000-1 mill kr
- ○ 1-1,2 mill kr
- ○ 1,2-1,5 mill kr
- ○ mer enn 1,5 mill kr
- ○ foretrekker ikke å si

28. Velg ditt yrke (velg alle mulige varianter) *

- [ ] Offentlig sektor (skoler, sykehus..)
- [ ] Tjenesteytende sektor (banker, hoteller, butikker, restauranter, transport)
- [ ] Landbruk
- [ ] Skog
- [ ] Fiskerinæring
- [ ] Akvakultur
- [ ] Annen industri (industri, bygg og anlegg, vedlikehold)
- [ ] Daglig leder eller bedriftseier
- [ ] Ikke-statlig organisasjon (frivillige organisasjoner)
- [ ] Forskning
- [ ] Arbeidsledig
- [ ] Pensjonert
- [ ] Annet

29. Hvis du er i arbeid, hva beskriver best din nåværende ansettelsessituasjon

- ○ Heltidsarbeid
- ○ Deltidsarbeid
- ○ Midlertidlig permittert
- ○ Søker arbeid

30. Hva er det høyeste utdanningsnivået du har fullført? *

- ○ Barneskole
- ○ Grunnskole
- ○ Videregående skole
- ○ Bachelograd/Cand mag
- ○ Mastergrad/ Hovedfag
- ○ Doktorgrad eller høyere
- ○ Foretrekker ikke å si

31. Har du medlemskap i organisasjoner? *

- ○ Fiske- og jaktklubber
- ○ Miljøorganisasjoner
- ○ Har ikke medlemskap
- ○ Annet

32. Hvor bor du? Angi postnummeret. *

Skriv inn svaret

33. Takk for at du fyller ut spørreskjemaet vårt!
Hvis du har spørsmål eller noe du vil legge til, så kan du skrive i boksen nedenfor.

Skriv inn svaret