DOES THE RECREATIONAL ANGLER CARE? ESCAPED FARMED VS WILD ATLANTIC SALMON

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ABSTRACT

The paper explores to what extent escaped farmed salmon from fish farms affect the willingness-to-pay for recreational fishing of Atlantic salmon in Norwegian rivers. The aim is to quantify the potential externality from escaped farmed species working through the demand for the natural stock of congeners. While the biological and genetic effects of escaped farmed salmon have been widely acknowledged, the potential economic consequences have received little attention. This study is a first attempt to close this gap by analysing the direct effect on the recreational use values. The empirical analysis is based on the results from a contingent valuation survey conducted in Norway. It is found that the presence of escaped farmed salmon in Norwegian rivers may have severe economic consequences on the willingness-to-pay for recreational fishing.

Keywords: Escaped farmed species, invasive species, willingness-to-pay, contingent valuation, recreational fishing, Atlantic salmon.

Introduction

During the last few decades, there has been increasing concern about invasive species in various ecosystems. Holmes (1998) argued that invasive alien species are the second most important cause of biodiversity loss worldwide, only after habitat alteration. Although the economic consequences of non-indigenous species are recognized as important, there have been few attempts to quantify them. This is due to a lack of good data, as well as uncertainties and measurement problems when facing the many components that are difficult to quantify accurately (Perrings *et al.* 2000). One of few exceptions is Pimentel *et al.* (2000&2005) who estimated total economic damages and associated control costs due to all invasive species in the USA to be up to $137 billion per year.

Quantifying the economic consequences of biological invasions is of obvious importance for policy making, and also provides crucial basic knowledge if well-informed management decisions with respect to invasive species are to be taken. This goes both to how much should be invested in prevention and damage control as well as to what extent actions that may induce new invasions should be allowed, e.g. with respect to the increasing interest in farming new species. For example, in Norway, 21 national farming free fjords were established in 2003 to prevent the escapees of farmed salmon from entering into some important salmon fjord systems (Ministry of the Environment 2002). However, there is an ongoing debate over whether to allow farming of other species such as cod in these salmon farming free fjords.

Several authors in Perrings *et al.* (2000) dealt with the economics of biological invasions. A general theoretical model set-up was given in Knowler and Barbier (2000). They constructed a bioeconomic model based on the diffusion and competition effects between invasive and native species. In a joint travel cost – contingent valuation study, Nunes and van den Bergh (2004) explored the extent to which people value protection against exotic species. They found that a marine program protecting against harmful algal bloom species along the coastland of Netherland made sense from an economic perspective as long as its benefits exceed its cost that were between 225 and 326 million Euro. In this paper, we analyze yet another potential concern, namely the influence escaped farmed species may have on the willingness-to-pay for recreational harvest of the natural habitants. More specifically, we study the effects that escaped farmed salmon may have on the willingness-to-pay for recreational salmon angling in Norway.

Norway has been the world leader in farmed salmon since this technique was pioneered in the early 1960s. Production has risen rapidly from about 600 tonnes in 1974 to about 700 000 tonnes today (Bjørndal 1990, Statistics Norway 2008). Salmon farming is one of the most important industries in rural Norway, with a yearly first-hand value (farmgate value) of about 17 billion Norwegian kroner (NOK) (2.2 billion EUR). However, since the very beginning of the salmon farming industry, salmon have unintentionally been escaped from net pens that are damaged by storms, seals, and otters, or by daily wear and tear. The number of accidental escapes decreased in the mid-1990s because of safety investments in the sea ranches. Nevertheless, approximately 400 000 salmon still escape yearly from fish farms in Norway (Table 1), a number exceeding the average total wild spawning stock (NOU 1999).

The wild Atlantic salmon stock is traditionally harvested by two different fisheries in Norway during its spawning run. First, the marine commercial fishery catches about 40% of spawning biomass in fishnets in the fjords and inlets. Then the remaining stock enters the rivers and is exploited by a recreational fishery. When the fishing season in the river closes, the remaining stock takes part in the reproduction process in the river in the late autumn.

Some important salmon rivers in Norway such as Etneelva, Vosso and Namsen rivers have very large shares of escaped farmed salmon in their spawning stocks, respectively 64.9%, 52.4% and 31.9% on average (NOU 1999). These numbers have drawn the attention that escaped farmed salmon may cause potential negative effects on the wild salmon populations. It is documented that spawning escaped farmed salmon (*EFS*) have a number of negative ecological effects on wild salmon. The most important effects are the spread of diseases and the mixing of genes through interbreeding, which affect the reproduction rate and growth of the wild salmon (NOU 1999). Because wild and raised salmon are genetically different, the escaped farmed salmon affects the wild Atlantic salmon stock through inbreeding (McGinnity *et al.* 2003). For example, given the present level of escaped farmed salmon in the wild salmon spawning stock, it takes approximately 3.3 generations of salmon to halve the genetic difference between the farmed and wild species (Fleming *et al.* 2000). Farmed salmon also digs in the natives' spawning nests, they tend to get more aggressive and risk willing offspring (NOU 1999). Further they increase the sea lice density of wild salmon (Grimnes *et al.* 1996).

In many respects, it may be impossible for different harvesters to separate the wild and escaped species that they catch. However, it is easy to discover whether there are genetic differences or variations between the wild and the farmed species through genetic investigation. Knowledge about the composition of the catch as well as the composition of the breeding stock is often available (again see Table 1). Thus, anglers may know the likelihood of getting a farmed over a wild salmon. Furthermore, harvesters may be concerned about the health of the wild stock due to crossbreeding when the share of invasive salmon in the breeding stock is high. This could relate directly to the existence value of the genetically different wild species or to the loss of biodiversity due to the gene flow from the farmed to the wild species. Another interpretation is that harvesters simply prefer to harvest "clean" or "pure" wild Atlantic salmon.

While the biological and genetic effects of escaped farmed salmon have been widely acknowledged, there are very limited, if not none, studies addressing the economic effects escaped farmed salmon may induce. This study is a first attempt to close this gap by analysing the direct effect on the recreational use values. The question can be asked: do anglers value escaped farmed salmon and wild salmon in their catches differently? Or do they perceive escaped farmed salmon as a "problem" at all? Hence, the aim of this study is to explore to what extent escaped farmed salmon influences the willingness-to-pay (WTP) for recreational fishing, everything else being equal. A contingent valuation survey is conducted to estimate the WTP associated with changes in the share of escaped farmed salmon in anglers' catches in Norway.

Ideally, we would want to reveal these preferences by analysing data on markets for recreational fishing in Norwegian rivers. However, due to the great diversity of supply arrangements in these rivers, market data give very limited information about the demand side (see Olaussen and Skonhoft 2008). The supply conditions may range from perfect competition to pure monopolistic cases, and where one typically may have different supply arrangements between rivers and also within each river. In addition, in many instances, the permits are provided as part of a package, including lodging and guiding etc., that makes the permit price different to reveal (Fiske and Aas 2001). The price of a typical one day fishing permit varies from NOK 50 to NOK 400, typically closer to NOK 100 in smaller rivers and NOK 300 in larger rivers. For example, Skonhoft and Logstein (2003) estimates that a typical fishing permit is sold for NOK 144 in rivers where landowners are price-takers and NOK 288 in rivers where landowners have monopolistic power. Altogether, we may conclude that a typical one-day permit is sold for about NOK 200, but that there are large variations. In the present study we analyse stated preferences data from a contingent valuation survey.

Table 1: Escaped farmed salmon (*EFS*) in Norwegian fisheries and river spawning stocks, 1989-2003.

Year	Total number of *EFS* (1000)	*EFS* share in river sport fishery (%)	*EFS* share in marine fishery (%)*	*EFS* share in spawning stock (%)
1989	-	7	59	35
1990	-	7	63	34
1991	-	5	59	24
1992	-	5	65	26
1993	498	5	67	22
1994	536	4	55	22
1995	240	5	56	29
1996	417	7	63	31
1997	506	9	79	29
1998	553	9	75	22
1999	348	6	66	15
2000	276	7	48	11
2001	272	7	46	11
2002	424	16	61	18
2003	379	-	35	13
2004	563	7	46	14
2005	762	6	47	13
2006	917	7	55	-
Average,	478	7%	58%	22%

Source: http://www.environment.no/no/Tema/Naturmangfold/Laks/Romt-oppdrettsfisk/ and http://www.ssb.no/english/subjects/10/05/nos_fiskeoppdrett_en/arkiv/nos_d401_en/

- Un-weighted average, coast+ fjord.

The rest of the paper is organized as follows. Section two describes the contingent valuation survey data and descriptive results. The econometric model, the estimation method, and the results are presented in section three. Section four summarizes our findings and presents discussions and conclusions.

The contingent valuation survey, data, and descriptive statistics

Contingent valuation method (CVM) uses survey questionnaires to elicit hypothetical WTP for different non-market commodities or policies, e.g. a specific change in an environmental quality. CVM involves directly asking people to respond to hypothetical questions in a hypothetical market situation and to state their preferences (Hanley *et al*. 1997). In this study, individuals are asked for their WTP for special hypothetical changes in the share of escaped farmed salmon in the rivers. Our main hypothesis is that, *ceteris paribus*, the WTP for recreational fishing of salmon is decreasing with increasing share of escaped farmed salmon in the rivers. As mentioned, since the anglers in most cases are not likely to detect if the salmon they catch is wild or reared; this knowledge comes from annual reports on average shares of farmed salmon in the different rivers. On the other hand, since the anglers in most cases do not know if the specific fish they catch is farmed or wild, we may alternatively suspect that anglers just consider a fish as a fish, no matter it is farmed or wild. Hence, the null hypothesis is that there are no WTP differences.

CVM is one of the most, if not the most, commonly used methods to measure economic values of non-market goods and service such as recreational resources. There is a rich variety of literature on CVM for recreational activities. Richardson and Loomis (2009) present an excellent and comprehensive overview of CVM. One of the most relevant articles for the present study is Whitehead *et al.* (2002) that applied CVM to estimate WTP for a proposed saltwater recreational fishing license among three recreational angler groups in North Carolina. They found the anglers' WTP for pursuing a license to be higher if the license fees could be used for improving the quality of the fishery and management. Another related article is Cantrell *et al.* (2004) which applied CVM to estimate WTP for increased catch rate resulting from a subsidized stock enhancement program on the windward coast of Oahu, Hawaii. Finally, a recent study by Heide *et al.* (2008) used CVM to estimate WTP for a nature protection program in the Netherlands.

The survey design and data

The contingent valuation survey was conducted by mail in 2005. The questionnaire was administered to 1,709 Norwegians that were randomly drawn from the Norwegian adult population (> 18 years). 711 returned their questionnaires after one reminder, and the response rate is about 42%.[1] Since the sampling was based on the general Norwegian population and the number of questions was large, the response rate received was as expected. In addition, a telephone interview was also conducted. In the telephone survey, 95 people answered among 149 interviewed, resulting in a response rate of 64%. The telephone response rate is hence fairly higher than the mail response rate. Nevertheless, the results from the telephone survey were not significantly different from the mail survey (see more details below). Comparing the survey data with socio-demographic statistics for Norway, we were unable to find major differences, and we therefore assume that the sample is representative of Norway (see Olaussen 2005 for a more detailed description). Since this study focuses on salmon recreational fishing, we only consider the responses from salmon anglers defined as those who had engaged in salmon recreational fishing at least once during the last 10 years. This means that only those familiar with buying the commodity in question are asked about their WTP as suggested by Mitchell and Carson (1989). Among the 1,709 potential respondents in the mail survey, 232 are characterized as salmon anglers representing almost 14% of the total number of potential respondents.

Other surveys on angling activity in Norway shows similar results, and Fiske and Aas (2001) estimates that among 8-12% of the total Norwegian population takes part in salmon angling. The reason why our result exceeds this estimate is probably the somehow wide definition of salmon anglers, that is, all anglers that have engaged in salmon angling at least once during the last decade is defined as a salmon angler in our study. Nevertheless, compared with the knowledge on salmon angling activity in Norway it seems like the response rate of salmon anglers in our study is very high.

In the questionnaire, the important questions for our purpose are the questions regarding the WTP for a one day angling permit with respect to different shares of escaped farmed salmon in the rivers. The questions relevant to this study on the WTP for escaped farmed salmon are summarized in Table 2 (translated from Norwegian to English). In addition, socio-economic characteristics of salmon recreational anglers such as age, gender, income and education,

[1] Only one reminder was sent out.

as well as other related attributes such as the perceived importance of wild salmon and how often the anglers go fishing (see below and Table 3) were collected. There are three scenarios representing different shares of escaped farmed salmon in rivers. Each scenario corresponds to 8 categories of WTP ranging from zero to over 1,000 NOK. Question B7 in Table 2 is the base scenario for WTP when all the salmon in the river is wild, $EFS0$, while B6 reports the results when half the stock consists of escaped farmed salmon, $EFS50$. Question B8 reports the results when all the salmon is escaped farmed, $EFS100$.

Table 2: Questions about willingness-to-pay for fishing permits under different escaped farmed salmon scenarios (translated from the original Norwegian questionnaire).

B6. *How much are you willing to pay per day-permit to fish in a river where the probability that the salmon you catch is wild is equal to the probability that it is farmed?*	
0 NOK per day………… ☐ 1	200 NOK per day…………………. ☐ 5
10 NOK per day……….. ☐ 2	400 NOK per day…………………. ☐ 6
50 NOK per day……….. ☐ 3	700 NOK per day…………………. ☐ 7
100 NOK per day……… ☐ 4	More than 1000 NOK per day……. ☐ 8
B7. *How much are you willing to pay per day-permit to fish in a river where there are no escaped farmed salmon?*	
0 NOK per day………… ☐ 1	200 NOK per day…………………. ☐ 5
10 NOK per day……….. ☐ 2	400 NOK per day…………………. ☐ 6
50 NOK per day……….. ☐ 3	700 NOK per day…………………. ☐ 7
100 NOK per day……… ☐ 4	More than 1000 NOK per day……. ☐ 8
B8. *How much are you willing to pay per permit to fish in a river where all the fish is escaped farmed salmon?*	
0 NOK per day………… ☐ 1	200 NOK per day…………………. ☐ 5
10 NOK per day……….. ☐ 2	400 NOK per day…………………. ☐ 6
50 NOK per day……….. ☐ 3	700 NOK per day…………………. ☐ 7
100 NOK per day……… ☐ 4	More than 1000 NOK per day……. ☐ 8

Descriptive statistics

First, we summarize the WTP results with respective shares of escaped farmed salmon, and present some descriptive statistics. Summary statistics are presented in Table 3. The first part of Table 3 reports the frequency of respondents associated with different WTP under the three scenarios. It is shown that the frequency distribution of WTP differ between three scenarios. The frequency in lower WTP categories is progressively higher with the increasing share of escaped farmed salmon, while the frequency at higher WTP categories is higher with the lower share of escaped farmed salmon. For instance, the number of respondents at category 1 and 2 (WTP NOK 0~10) increases substantially from scenario $EFS0$ to scenario $EFS100$. Further, 9 respondents report that they are willing to pay >NOK 1000 in scenario $EFS0$, while none of the respondents were willing to pay more than NOK 700 in scenario $EFS50$ and NOK 400 in scenario $EFS100$. The highest frequency for the scenarios $EFS0$, $EFS50$ and $EFS100$ is 61, 78 and 117 corresponding the categories of NOK 200, NOK 50 and NOK 0, respectively. The last part of Table 3 reports the average WTP under the three scenarios. The mean WTP for the scenarios $EFS0$, $EFS50$ and $EFS100$ are NOK 255, 109 and 49, respectively[2]. These descriptive statistics clearly indicates that the WTP for a one-day fishing permit decreases with the increasing shares of escaped farmed salmon in rivers.

Table 3: Summary statistics, willingness-to-pay under three scenarios.

Frequency / EFS share	Willingness-to-pay for a one-day permit (NOK)								No. of	Mean
	0	10	50	100	200	400	700	>1000	Obs	WTP*
$EFS0$	22	8	38	55	61	31	7	9	231	255
$EFS50$	45	23	78	50	30	5	1	0	232	109
$EFS100$	117	39	42	21	10	2	0	0	231	49

* Mean WTP values (in NOK) are estimated based on interval censoring and hence corresponds to the results from the grouped data regression model with only EFS share dummies included (For example *EFS50=109* in table 3 mirrors 255-146 in table 7).

Payment card questionnaires as described above have been criticised for several reasons. On key criticism is the problem related to anchoring and dependency between answers when the respondents are asked a series of related questions (Mitchell and Carson 1989). To reveal if this is a relevant problem in our case, the telephone survey was designed different from the mail survey. The respondents were provided with the same information as in the mail survey, but only one of the willingness to pay questions (question B8, table 2) regarding the share of farmed salmon was asked in order to check if dependency between answers may have affected the WTP levels. The correspondence between the answers from the mail survey (with the sequence of questions B6, B7 and B8) and the telephone interview (only question B8) were good. The results suggest that there are no significant differences between WTP levels in the telephone and mail surveys[3]. Hence, we conclude that the potential problem of dependency between answers seems to be of minor importance here. It should be noted, however, that the telephone respondent group in our sample consists of only 17 salmon anglers, so the generality of this result should not be overstated.

Willingness-to-pay model

This study focuses on the effect of the share of escaped farmed salmon on anglers' WTP, which have been statistically described in Table 3. However, other variables that economic theory and previous studies would suggest affect the willingness to pay for angling are included. These are socio-economic characteristics of salmon recreational anglers such as age, gender, and income, as well as other related attributes such as the perceived importance of wild salmon and how often the anglers go fishing (Cantrell *et al.* 2004; Johnston *et al.* 2006). The WTP function is defined by a simple linear functional form given by:

$$(1)\quad P_i = \alpha + \beta_1 EFS50_i + \beta_2 EFS100_i + \beta_3 imp_i + \beta_4 fishy_i + \beta_5 female_i + \beta_6 income_i + \beta_7 age_i + \varepsilon_i$$
$$i = \langle 1; 226 \rangle$$

Note that the dependent variable P_i is a latent variable as the actual maximum WTP amounts are not directly observable. This is because the WTP amounts are collected from a payment card where the respondents choose the value that best represents their maximum WTP. The payment card approach is hence of the type Haab and McConnell (2003) classify as: "Pick the maximum amount you are willing to pay". Since the true maximum WTP lies between the amount picked and the next amount on the payment card, these WTP results define WTP intervals. This means that the observed information about the dependent variable is that it falls within a certain interval of the underlying real line. The real line is divided into $k(k = 1,..., K)$ mutually exclusive and exhaustive intervals, the *k*-

[2] Based on the interval censoring estimation technique utilising the maximum likelihood estimation approach (see below)

[3] The t-test statistics for comparing means from the two samples is t=-1.389 (p=0.166).

th being given by (A_{k-1}, A_k). In addition, the data is right censored due to the open ended upper interval, that is $A_k = \infty$. By utilizing the information on which of these intervals the dependent variable falls into, consistent and efficient parameter estimates can be achieved by grouped data regression (Stewart 1983).[4] In the following, equation (1) is therefore tested by a grouped data regression model.

Dummy variables are used for the shares of escaped farmed salmon, *EFS50* and *EFS100*. The dummy $EFS50 = 1$ when the share of escaped farmed salmon is 50% (question B6, Table 2), and zero otherwise, while $EFS100 = 1$ when the share of escaped farmed salmon is 100% (question B8, Table 2), and zero otherwise. The base group is hence $EFS0$ with no escaped farmed salmon (question B7, Table 2). Since each respondent is recorded with three answers due to the design of the study ($EFS0$, $EFS50$ and $EFS100$), a standard grouped data regression model underestimates the standard deviations as n is exaggerated (3 x number of respondents). Following, we present the results from the clustered grouped data regression model, where the data is clustered with respect to each respondent, leaving us with a sample of *226* clusters [5] and robust standard errors ($\varepsilon_i \sim N(0, \sigma^2)$). Further α is the constant term while the variable *female* reports female respondents as a dummy variable, meaning that the variable is 1 if the respondent is a female and zero otherwise. The variable *imp* reports the respondents' subjective measure of how important they think it is to sustain a viable wild salmon stock in Norway. The variable is divided into four categories ranging from very important to not important. The variable *fishy* measures how frequent the anglers normally fish salmon per year. The respondents are classified into five categories ranging from those who normally fish zero times per season to those who go salmon fishing more than 50 times per year. The *age* variable is measured on a yearly scale. The *Income* variable was collected as a range variable in the survey, were respondents reported net monthly income interval (in NOK: 0-10000, 10000-20000, 20000-25000, 25000-30000, 30000-35000, 35000-45000, >45000). Table 4 sums up the variable definitions and reports more details about the categories of each variable. The coding rule applied is very simple as we have just used the middle value of each interval for the grouped variable.[6] Table 5 reports the socio-economic characteristics of salmon recreational anglers in the sample.

The mean age of respondents is 44 years. Among the angling respondents, 28% are women and 72% are men. The distribution of household gross monthly income among respondents is quite spread with 10% earning less than NOK 10,000, 26% between NOK 10,000 - 20,000, 19% between NOK 20,000 – 25,000, 13% between NOK 25,000 – 30,000, 11% between NOK 30,000 – 35,000, 11% between NOK 35,000 - 45,000, and 10% higher than NOK 45,000. The majority of respondents (86%) consider having wild Atlantic salmon in Norwegian rivers as very important, 13% think it is important, and only 1% view it less important. Most of the anglers report that they usually fish salmon one to five days per season, while 29% reports that they fish salmon between five and twenty fishing days per season. Altogether, only 9% fish salmon more than 20 days per year.

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[4] Stewart (1983) developed a Least Squares algorithm for attaining the Maximum Likelihood estimator and combined this with a moment estimator of the OLS regressors in what he referred to as a two-step estimator. The procedure is later known as the grouped data regression model. See also Caudill and Jackson (1993) for an extension to the heteroscedastic case.

[5] This number is different from the observed number, 231 used for descriptive statistic analysis in Table 3. This is because 5 observations were removed due to incomplete information on variables.

[6] Note that the >45 000 NOK category is coded as 50 000. Note also that applying the lowest value of each interval yields no qualitative different results.

Table 4: Variable description

$EFS50$	=1 if share of escaped farmed salmon in stock is 50%, 0 otherwise
$EFS100$	=1 if share of escaped farmed salmon in stock is 100%, 0 otherwise
female	=1 if female angler, 0 otherwise
imp	How important is it for the angler that there is wild Atlantic salmon in Norway; very important, important, not particularly important or not important.
fishy	How frequent the angler normally fish for salmon per year; 0, less than 5 days, 5-20 days, between 20 - 50 days, or more than 50 days.
income	The household gross monthly income; less than NOK 10 000, NOK 10-20 000, NOK 20-25 000, NOK 25-30 000, NOK 30-35 000, NOK 35-45 000, more than NOK 45 000.
age	The age of the angler.

Empirical results

The results from the clustered grouped data regression model are reported in Table 6[7]. It can be seen that the coefficients match to the expected signs and that most of them (except age) are significantly different from zero at the 5% level. The shares of farmed salmon, gender and importance of wild salmon are negatively correlated with the WTP, and significant at the 1% level, while the frequency of fishing and income are positively correlated with the WTP, and significant at the 5% level. The dummy variable for the WTP for a one-day fishing permit in a river where half the stock consists of escaped farmed salmon, $EFS50 = 1$, is on average NOK -148. Furthermore, the dummy for all the fish being escaped farmed salmon, $EFS100 = 1$ the WTP is NOK -208. Relative to the constant term of NOK 242 where all the salmon is wild, and all other explanatory variables are zero, the consequences seem to be relatively large. Perhaps more informatively, the WTP for a one-day fishing permit decreases by about 60% if half the stock is farmed and by about 85% if the whole stock is farmed, compared to the WTP when the total stock is wild. These results also suggest that the negative demand effect of escaped farmed salmon on the recreational anglers' WTP is diminishing. However, more detailed data is required to test for such non-linearities. The McKelvey and Zavoina`s R-squared for the model is 0.28[8]. The regression model is also run by including only the EFS share as explanatory variable. The results are reported in Table 7. It should be noted that the coefficients and constant term are very similar to those in Table 6. The McKelvey and Zavoina`s R-squared for the model is 0.23. Hence, this indicates that the EFS shares are quite important relative to our other explanatory variables in determining the anglers' WTP.

[7] The empirical analysis was performed with STATA/IC 10.0. Grouped data regression is found labelled interval regression in the clustered regression routine.
[8] The Mckelvey and Zavoina measure of fit is provided by the fitstat post estimation module for STATA developed by Long and Freese (2006). See also: http://www.ats.ucla.edu/stat/stata/dae/intreg.htm

Table 5. Socio-economic characteristics of salmon recreational anglers and associated attributes

Variable	Mean	Percentage
Gender		
Women		28
Men		72
Household gross monthly income		
< NOK 10,000		10
NOK 10,000 – 20,000		26
NOK 20,000 – 25,000		19
NOK 25,000 – 30,000		13
NOK 30,000 – 35,000		11
NOK 35,000 – 45,000		11
> NOK 45,000		10
Fishing days per year		
0		23
1- 5 days		49
5 – 20 days		29
20 – 50 days		6
> 50 days		3
Importance of wild salmon		
Very important		86
Important		13
Not particularly important		1
Not important at all		0

To get a grip about the extent to which escaped farmed salmon affects the WTP for salmon fishing, we compare the effects of our farmed share dummies with the effect of changes in the other significant explanatory variables. For example, while the WTP is reduced by NOK 148 when half the salmon stock is farmed, *EFS50*, it is on average about NOK 40 lower when the angler is a female. As mentioned above, a typical fishing permit in Norwegian rivers costs somewhere around NOK 200, although large variations exists. This underlines the magnitude of the influence caused on the WTP by escaped farmed salmon. Furthermore, the reduced WTP from respondents reporting lower preferences for a wild salmon stock (the *imp* variable), measured by e.g. the difference between those responding very important and those responding important on this question, is NOK 44. On the other hand, the anglers that fish more frequently (*fishy*) typically reports a higher WTP for fishing permits, meaning that those fishing 5-10 times per season on average report a NOK 18 higher WTP than those fishing less than 5 times per season. Finally, an average increase in the gross monthly household income of NOK 10 000 increases the WTP for a daily fishing permit with about NOK 14. This means that the anglers with a monthly gross income of less than NOK 10 000 are willing to pay on average about NOK 78 less than those earning more than NOK 45 000. Hence, the income effect on the anglers' WTP of such a large income difference seems to be about half as important as if half the stock consist of farmed salmon.

Table 6: Results, clustered Grouped data regression model of willingness to pay for a one-day fishing permits. (number of clusters 226).

	Coef.	Std. Err.	Z	P>z	95% conf. interval	
constant	241.96	41.19	5.87	0.00	161.23	322.69
EFS50	-147.73	15.83	-9.33	0.00	-178.75	-116.71
EFS100	-207.89	17.62	-11.8	0.00	-242.42	-173.36
imp	-44.30	14.07	-3.15	0.00	-71.88	-16.72
fishy	18.36	8.28	2.22	0.03	2.13	34.58
female	-39.45	14.82	-2.66	0.01	-68.49	-10.41
income	13.53	4.31	3.14	0.00	5.09	21.97
age	-0.28	0.50	-0.57	0.57	-1.26	0.69

McKelvey and Zavoina's R^2: 0.28

Table 7: Results, *clustered Grouped data regression model of willingness to pay for a one-day fishing permits. (number of clusters 232)*

	Coef.	Std. Err.	Z	P>z	95% conf. interval	
constant	255.29	17.42	14.65	0,00	221.15	289.43
EFS50	-145.59	15.47	-9.41	0,00	-175.91	-115.27
EFS100	-205.62	17.30	-11.88	0,00	-239.53	-171.71

McKelvey and Zavoina's R^2: 0.23

Discussion and conclusion

This study has examined the effects of the shares of escaped farmed salmon in a river on the WTP for Atlantic salmon recreational fishing in Norway. A contingent valuation study was used to estimate the salmon recreational angers' WTP when salmon in river comprises zero, 50% and 100% of the escaped farmed salmon. It is found that the WTP is reduced by about 60% (NOK 148) and 85% (NOK 208) when the shares of escaped farmed salmon increases from zero to 50% and 100%, respectively. The results strongly indicate that the WTP for recreational fishing of Atlantic salmon is negatively related to the proportion of escaped farmed salmon in the rivers. The analyses also reveal that other factors such as the socio-economic characteristics and attitudes of salmon anglers have effects on their WTP. To the authors' knowledge, this study is the first attempt to explore the economic consequences of escaped farmed salmon in terms of the anglers' WTP for fishing permits although the ecological consequences of the problem have been widely recognised in the biological literature.

The economic consequences in absolute terms may be severe. In Norway approximately 1.5 million one-day fishing permits are sold each year (Mørkved and Krokan 2000), if we use the average reduction in the WTP, NOK 148 as an example, the total loss from selling fishing permits will be around NOK 222 million when half the salmon stock in the river consists of escaped farmed salmon. Hence, the consequences can be quite dramatic for the anglers, and hence the landowners providing fishing permits in the river valleys of Norway. We should also keep in mind that this is only the direct consequences with regard to angler and landowner surplus. The total economic impact must also account for other use values such as the reduction in indirect benefits as from lodging and tourism in general. Non-use and existence values are also totally neglected in the present study. Still, even this simple analysis may have profound implications in by providing incentives for imposing management strategies to reduce the escaped farmed salmon in rivers.

This study has addressed to what extent escaped farmed species may affect the anglers' WTP. This finding may be transferable to other situations where escaped farmed animals mix with their wild congeners, or where an ecosystem faces a yearly influx of invasive species for any reason. The increasing aquaculture production of both salmon and other species worldwide highlights the importance of addressing this issue.

However, there are some limitations regarding the method, data and analyses. In this study the WTP was linearly regressed on the shares of escaped farmed salmon, gender, importance, fishing frequency, income, and age. However, other functional forms such as linear-quadratic, log-log may be applicable. Such tests can be done with more detailed data. Our study only includes three scenarios: zero, 50% and 100% shares of the escaped farmed salmon, but future studies should include more WTP questions under additional share of escaped farmed salmon scenarios to investigate if there is a diminishing effect over the whole possible range. Additionally, the results presented here are based on answers from 226 Norwegian salmon anglers only. Future studies should include anglers from other countries, e.g. foreign tourist anglers, and examine if they state the same attitudes with respect to escaped farmed salmon. If so, the consequences for the whole fishing tourism sector may be severe, and moreover, the same consequences may be found for other farmed species like cod and halibut.

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