Households´ willingness-to-pay for improved fish welfare in breeding programs for farmed Atlantic salmon

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Abstract

There is a growing concern for the environmental consequences of fish farming and the welfare of farmed fish. Current breeding programs typically focus on profitability through emphasizing fast growth of the fish. This research, however, find that a representative sample of Norwegian households are willing to pay an increased price for farmed Atlantic salmon that is selected for traits related to fish welfare. In an internet survey, a random and representative sample of Norwegian households were asked to choose among breeding programs for farmed Atlantic salmon that differed with regards to costs and the following four traits related to fish welfare; frequency of deformities (Deform), frequencies of injuries (Injur), resistance to salmon lice (*Lepeophtheirus salmonis*) (Lice) and resistance to diseases (Health). The survey participants were given six different choice sets, where they had to choose one of three salmon breeding programs in each set. The programs differed with regards to whether each of the traits was selected for ("Yes" or "No"). One of the breeding programs was status quo in all choice sets, i.e. at zero cost animal welfare was not selected for. The cost of the breeding program was either expressed in terms of increased cost of purchasing salmon per household per year (consumer-version) or increased tax per household per year (citizen-version) in a split sample. The average willingness to pay (WTP) for the citizen version was highest for Lice (1271 NOK) followed by Health (1011 NOK). The WTP for Deform and Injur were nearly the same (560 NOK and 548 NOK). The ranking of the WTP for the four different traits was the same for the citizen version as for the consumer version, but the mean WTP estimates for each attribute in the consumer version were approximately twice as high for the citizen version. This study shows that there is a high WTP among Norwegian citizens and consumers for farmed Atlantic salmon which is selected for better fish welfare.

1. Introduction

Consumers, producers and authorities are increasingly concerned about fish welfare (Damsgård, 2008). Animal welfare can be defined as the animals' state in regards to its ability to cope with the environment (Broom, 1991). Fraser (2003) presents a more broad definition and describes how animals should be raised to ensure good animal welfare (e.g. animals should be allowed to lead relatively natural lives). Olesen et al. (2011) argue that animal welfare also includes positive experiences and stimuli in addition to absence of suffering. Studies have shown that consumers are willing to pay for improved fish welfare. Solgaard and Yang (2011) for example found that 48% of the participants in a Danish survey were willing to pay a price premium for rainbow trout with improved welfare. On average, Norwegian consumers prefer animal welfare labelled (Freedom food) salmon to conventional salmon. Olesen et al. (2010) found that Norwegian consumer were willing to pay a price premium of 2 Euro per kg filet. In addition to animal welfare, factors such as ethics and moral considerations also influence societal acceptability of production (Frewer et al., 2005).

The growing public concern about fish welfare is a relevant consideration for aquaculture breeding programs. Breeding affects fish welfare through genetic changes in traits related to fish welfare. Fish welfare is indirectly taken into account in breeding programs for Atlantic salmon by selecting for traits such as resistance to diseases and survival. The actual genetic change obtained in the traits is determined by the genetic parameters (heritabilities and correlations between traits) and the economic value for each trait in the breeding goal. The economic values or weights on individual traits in the breeding goal are usually derived from market prices using profit equations (Nielsen et al., 2011). However, animal welfare is a public good which is only partly traded in the market. If consumers are willing to pay for improved fish welfare, market prices will be influenced. In order to be able to obtain a price premium for fish with improved welfare traits, such fish in the stores must be labelled according to level of fish welfare and for each individual trait in the breeding goal. Also, consumers do not see animal welfare in food production as their responsibility (Kjørstad, 2005), but direct the responsibility to the government, the producers, and the retailers. In addition, consumers may find fish welfare important, without necessarily changing their fish consumption decisions (Verbeke et al., 2007). Because ethical values of fish welfare may not be directly available from the market, studies of households' willingness to pay (WTP) for improved fish welfare are needed (Olesen et al, 1999; Nielsen et al., 2011).

While a few studies exist on consumer perceptions of farmed fish and willingness to pay for fish welfare (Olesen et al. 2010; Solgaard and Yang, 2011) to our knowledge, no studies have evaluated consumers and citizens willingness to support breeding programs aiming at improving fish welfare. Preference techniques have previously been used to estimate farmer preferences for cattle traits (Tano et al., 2003; Würzinger et al., 2006).

This study elicits households´ preferences in terms of their WTP for breeding programs intended to improve the welfare of farmed salmon. We analyze survey data including a choice experiment with a random, representative sample of Norwegian households. The survey asked respondents to choose among breeding programs for farmed Atlantic Salmon that differed with regards to costs and traits related to fish welfare. Households' WTP for welfare traits in salmon breeding programs are estimated using a random parameter logit model.

2. Material and Methods

2.1. Survey

The Internet survey used in this study has three main sections. The first section contains questions regarding knowledge and attitudes about fish welfare and fish farming. The second section includes the choice experiment. The third section includes some more general attitude questions as well as questions eliciting socio-demographic characteristics.

TNS Gallup sent the survey to a random representative sample of Norwegian households in November and December of 2010. TNS Gallup's representative panel of 60.000 Norwegian citizens of 18 years age and above had agreed to participate in surveys, and was used for constructing a representative national sample. Respondents were contacted via an e-mail containing a link to the survey and were given one reminder. The response rate in terms of completed surveys relative to initial contacts was 33 percent. The survey resulted in a representative sample of responses from 2147 Norwegian households. Different subsamples were used to address different methodological questions of experimental design. This paper is based on a subset of 1544 of these observations, which used our main choice experiment design with four fish welfare traits.

2.2. The choice experiment

2.2.1. Breeding programs and welfare traits in the choice experiment

In the choice experiment, respondents were asked to choose among three different breeding programs that differed with regards to costs and traits related to fish welfare. Four traits were included as breeding attributes in the choice experiment: (1) fewer deformities, (2) less aggressive fish resulting in fewer injured fish, (3) improved resistance to salmon lice (*Lepeophtheirus salmonis*), and (4) improved resistance to infectious diseases. These four traits were chosen since they all affect the welfare of the fish and are important in Norwegian salmon production. In addition, the traits show genetic variation and they are feasible to record at reasonable costs.

In the survey design process, a concern was how to present the levels of these traits. We found that using frequencies of these traits would be difficult to fully understand for someone unfamiliar with breeding programs. Therefore, each breeding program presented in the choice experiments state whether or not that specific trait would be selected for (Yes or No). In addition to the four welfare traits, the associated monetary cost of that breeding program is included as a fifth attribute permitting the estimation of the willingness to pay for fish welfare traits.

The choice experiment had two versions: for approximately half of the sample (n = 771) the cost attribute was presented as an extra earmarked tax, NOK per household per year (*citizen*-version). For the other half of the sample (n = 773), the cost is presented as an extra cost of purchasing farmed salmon, NOK per household per year (*consumer*-version). The levels for the cost variable for both the consumer and the citizen version of the sample were: (100, 300, 500, 700, 900, 1100, 1300, 1800 NOK) where 100 NOK corresponds to 12.6 Euro or 16.7 USD in December 2010 when the survey was performed. These levels were chosen based on focus groups to assure that the range of the levels of the cost variable would cover the expected range of households' WTP. Thus the cost variable does not reflect the real cost of the breeding program but was designed to estimate households' maximum WTP for these fish welfare attributes. In addition to the two alternative breeding programs, each choice set included a *status quo* alternative: at zero cost there would be no breeding program initiated to improve salmon welfare as the breeding program would only focus on improving growth rate of the salmon.

2.2.2. Design of choice experiment

With four of the trait attributes having two levels and with eight levels for the cost attribute (not considering the status quo alternative), a full factorial design of this choice experiment has 128 profiles ($2^4 \times 8$), and thus, would require 64 choice sets each with two profiles (alternative breeding programs). Answering a large number of choice sets may result in respondent fatigue (Caussade *et al.*, 2005). Therefore, the choice experiment was designed using a fractional factorial design where the number of profiles was reduced to 48 and thus 24 different choice sets were constructed. The profiles used in the choice sets were chosen using the SAS procedure MktEx (Kuhfeld, 2009). The 24 choice-sets were randomly blocked into four groups each with six choice sets. Each survey (consumer or citizen-version) contained one of these groups of six choice sets.

2.2.3. Experimental procedure

The choice experiment section of the survey introduced the salmon breeding programs. This section stated that breeding programs are used to change the genetic composition of farmed salmon, and that so far the emphasis has mainly been rapid growth and as a result, better profitability. Then respondents were asked to consider breeding programs aimed at improving the quality of life for farmed salmon while trading-off rapid growth and profitability. The survey further states that the Government, the fish farming industry, and the Norwegian households, will cover the extra costs of this program.

Before discussing the four traits in the breeding program, the Internet survey displayed a picture of a healthy salmon. Thereafter the four welfare traits in the breeding program were introduced. First, skeletal deformities were discussed. A photo of a fish with a humpback was shown and the associated text discussed that the occurrence of such deformities can be reduced through breeding. The text further stated that deformities likely cause pain and discomfort for the fish through their effect on swimming and feeding abilities as well as oxygen uptake. This attribute is denoted *Deform*. Second, a picture of a salmon with injured fins was displayed. The associated text discusses how fin injuries were caused by aggressiveness among fish stocked in pens. Aggressiveness is believed to reduce salmon welfare through fear, painful bite injures, and wounds. Finally, it is stated that aggressiveness could be reduced through breeding programs. This attribute is denoted *Injur*. Third, a salmon infected by the parasite Salmon Lice was depicted. The associated text states that the parasite attaches to the skin of the salmon skin and survives by consuming skin, mucus and blood from the fish. The parasites spread among farmed salmon and from farmed to stocks of wild salmon in local rivers. To combat the parasite, fish farms typically use chemicals that also contaminate the surrounding waters. Salmon breeding programs can improve resistance to Salmon Lice infections. This breeding program attribute is denoted *Lice*. Finally, a salmon affected by bacterial infection was shown. The associated text states that a salmon is susceptible to a number of virus and bacteria, which can cause fish to suffer and die. The text continued by stating that breeding programs can make salmon more resistant to diseases and that this would cause less suffering for fish, less use of medications, and ultimately less traces of medications in the fish to be consumed. This attribute is denoted *Health*.

After the introduction of the welfare traits, respondents were presented choice sets and asked to choose between two alternative breeding programs (Alt1, Alt 2) that emphasized at least one welfare trait at a positive cost to the household or they could choose the status quo alternative (SQ) at a zero cost.

2.3. *Econometric analysis*

Willingness to pay is estimated using an additive random utility model and a random parameter logit model. In the additive random utility model the utility of alternative *j* to individual *i* is given by $U_{ij} = V_{ij} + \varepsilon_{ij}$ where V_{ij} is the deterministic component and ε_{ij} is a random component. Alternative *j* is chosen if the individual has the highest utility of that alternative. In a Random Parameter Logit (or mixed logit) U_{ij} is specified as (Cameron and Trivedi, 2009):

$$U_{ij} = x_{ij}'\beta_i + z_i'\gamma_{ji} + \varepsilon_{ij}\,, \qquad (1)$$

here x_{ij} is a vector of attribute levels and z_i is a vector of individual specific characteristics, and β_i and γ_{ji} are random parameters. This application assumes that $\beta_i = \beta + v_i,\ v_i : N(0,\Sigma_\beta)$ and $\gamma_{ji} = \gamma_j + w_{ji},\ w_{ji} : N(0,\Sigma_{\gamma_j})$. Substituting these terms, the equation for U_{ij} becomes:

$$U_{ij} = x_{ij}'(\beta + v_i) + z_i'(\gamma_j + w_{ji}) + \varepsilon_{ij} = x_{ij}'\beta + z_i'\gamma_j + x_{ij}'v_i + z_i'w_{ji} + \varepsilon_{ij}\,, \qquad (2)$$

where the term $x'_{ij} v_i + z_i'w_{ij} + \varepsilon_{ij}$ is a combined error term that permits for correlation between alternatives. The coefficients of the model in equation (2) (β and γ) were estimated for both the citizen version and the consumer version using the mixlogit command in Stata (Hole, 2007). The estimations each used 500 Halton draws (Hole, 2007). The four breeding attributes were assumed to be normally distributed, and the monetary attribute was assumed to be non-random. Since any variable that is constant across alternatives will drop out, socio-demographic attributes were interacted with breeding program attributes before including them in the model. Thus, new variables $S_{ji} = z_i \times x_{ij}$ were defined. Only statistically significant interaction variables were included in the models used in estimation of willingness to pay (WTP).

The average WTP for breeding program attribute *j* = *A* was calculated as:

$$WTP = -2 \times 1000 \times \left(\frac{\hat{\beta}_A + \hat{\gamma}_A'S_{Ai}}{\hat{\beta}_M + \hat{\gamma}_M'S_{Mi}} \right)\,, \qquad (3)$$

where subscript M denotes the monetary attribute and $\hat{\beta}_A$ is the estimated coefficient of attribute A, $\hat{\gamma}_A$ is the vector of estimated coefficients of the interactions with attribute A, $\hat{\beta}_M$ is the estimated coefficient of the monetary attribute, and $\hat{\gamma}_M$ is the estimated coefficient of interactions with the monetary attribute. The factor of two is included because the breeding program attributes are dummy variables (Yes or No) and the factor of 1000 is included because the cost variable was scaled down by a factor 1000 in the estimations. Because the status quo alternative had all "No"s and a cost of "0 NOK/year" the Willingness to Pay (WTP) for each attribute is interpreted as the total annual willingness to pay (WTP), or alternatively, implicit price for the presence of that attribute in the breeding program.

2.4. Data

The representative sample included both people who eat and who don't eat fish (1.9% and 1.8 % of the respondents for the consumer-version and the citizen-version did not eat fish), as well as people who chose not to purchase farmed salmon. The average age of the respondents is 45 for the consumer-version and 43 for the citizen-version. In the full sample, the minimum age was 18 and the maximum age was 87. For both data sets nearly 30% had a college or university degree. The income for the household was somewhat higher for the citizen-version (669,799 NOK) than for the consumer-version (643,624 NOK). There was on average 2.5 and 2.6 persons in each household.

Observations where respondents either used very short time or very long time were dropped (Alberini et al., 2004). The cut-offs applied were less than the first percentile of time and more than the 99th percentile of time for reading about the salmon welfare traits. The lower cut-off (the first percentile) is 2.5 seconds.

3. Results and discussion

The WTP estimates for the citizen and the consumer versions are reported in Table 1 and 2, respectively. Starting with the citizen-version, where the cost of the changes in the breeding program would be covered through earmarked taxes, the average WTP was highest for the *Lice* attribute (1271 NOK/yr) followed by the *Health* attribute (1011 NOK/yr), although these amounts were not statistically different. The WTP for *Deform* and *Injur* were close in value (560 NOK/yr and 548 NOK/yr), respectively, and were significantly less than the WTP amounts for *Lice* and *Health* (p-value 0.05). Converted to monthly cost per household, the WTP amounts are 106 NOK for *Lice*, 84 NOK for *Health*, 47 NOK for *Deform,* and 46 NOK for *Injur*. For a household that consumes farmed salmon 2-3 times a month, which is the most common rate of consumption reported in the survey, these amounts translate to: 42 NOK (*Lice*), 34 NOK (*Health*), 19 NOK (*Deform*), 18 NOK (*Injur*), or a total of 113 NOK per meal. The high WTP for *Lice* and *Health* is most likely reflecting that these breeding attributes improve fish and human welfare as well as the environment. Improving salmon resistance to lice reduces suffering for the fish and also reduces the amount of chemicals released in nature. The *Health* attribute reduces the prevalence of fish diseases and the need for antibiotic treatments in salmon farming.

The ranking of WTP for the different trait attributes was the same for the citizen version as for the consumer version, but the mean willingness to pay estimates for each attribute in the consumer version were approximately twice as high as for the citizen version. One reason for the higher estimates in the consumer version may be that respondents likely consider reducing their salmon consumption if salmon were to become more expensive as a result of improved fish welfare. Furthermore, respondents who don't consume salmon have, for the consumer version, an incentive to choose expensive breeding program because a higher price does not affect them, while with an earmarked tax (citizen-version) the respondents pay whether salmon is consumed or not. The WTP of the citizen-version may further be lower compared to the consumer version if there is aversion to additional taxes among the respondents. Thus, it is expected that the citizen version will produce lower estimates than the consumer version. Early evidence in support of these arguments are that while the citizen and the consumer versions only differ with respect to payment vehicle, the status quo alternative (0 NOK/yr) was chosen in 28 percent of the choice experiment questions for the citizen-version while the status quo alternative was chosen for only 13 percent for the consumer-version. Thus, the status quo alternative is seen as more attractive when the respondent is faced with increased taxes as opposed to increased prices. The statistical support for these arguments will be explored in future analysis. Yet, taking all these factors into consideration, the citizen version is currently our preferred version.

The WTP for different groups of households for the citizen and consumer version are also reported in table 1 and 2. The WTP of these groups were calculated using the estimated parameters by inserting the appropriate values of the covariates in the WTP formula in equation (3). For instance, if women's WTP for the Injur attribute is to be estimated, then the dummy variable for female is set equal to one and this adjusts the values of the interactions between Injur and female and between cost and female. The other interactions with the variables Injur and Cost are evaluated at their average value. Note that interactions with demographic attributes were only included in the regressions used to estimate coefficient used in the WTP calculations if the interactions were found to be statistically significant. Thus, if the interactions between female and injur and between female and cost are not significant, the estimated WTP of females will not differ from the estimated WTP of males. This is the case for the WTP of men and women for the health attribute in the consumer-version (see Table 2).

4. Conclusion

This study applies a choice experiment on a random sample of the norwegian population to estimate WTP for salmon selected for improved fish welfare. In general, the WTP for breeding programs aiming at improving fish welfare are high, ranging from 560 NOK to 1271 NOK. The estimated values of WTP for all the attributes included in the experiment are significantly greater than zero ($p<0.01$). The highest WTP was found for salmon bred to be resistant to salmon lice. Extensions of this study will convert the WTP estimates to economic values that can be included in the breeding goals for salmon.

Two versions of the choice experiment were administered: a citizen version with the payment vehicle as an earmarked tax and a citizen version with the payment vehicle as an increased price. Interestingly, the estimated WTP values are approximately two times greater for the consumer version than for the citizen version. Future work will aim to explain statistically the differences in WTP estimates for the citizen and the consumer versions.

Table 1. WTP in Norwegian Kroner (NOK) for breeding program attributes for various respondent groups for the Citizen-version. All WTP estimates are significantly greater than zero (p<0.001).

Attribute	**Average Household**	**Females**	**Males**	**At least college/ university education**	**Less than college/ university education**	**Lower Age = 32**	**Higher Age = 59**	**Low Inc Hhinc = 400 NOK**	**High Inc Hinc = 800NOK**
Deform	560.0	791.9	304.5	624.0	486.1	475.7	710.9	507.4	594.6
Injur	547.6	547.6	547.5	609.7	475.0	464.8	694.6	495.8	580.9
Health	1010.5	1238.2	759.2	798.1	712.1	857.8	1282.1	915.1	1072.2
Lice	1271.0	1505.4	1012.2	1415.4	1102.6	1078.9	1612.5	1151.0	1348.6

Table 2. WTP for breeding program attributes for various respondent groups for the Citizen-version. All WTP estimates are significantly greater than zero (p<0.001).

Attribute	**Average Household**	**Females**	**Males**	**At least college/ university education**	**Less than college/ university education**	**Lower Age = 32**	**Higher Age = 59**	**Low Inc Hhinc = 400K**	**High Inc Hhinc = 800K**
Deform	1284.1	1535.4	1006.7	937.6	1523.8	963.1	1900.6	1019.6	1544.0
Injur	1290.8	1523.6	1033.9	942.5	1531.8	968.1	1910.5	1024.9	1552.0
Health	2440.6	2440.6	2440.6	2162.5	2632.9	1830.4	3612.3	1937.8	2934.0
Lice	2612.0	2612.0	2612.0	2264.3	2852.6	2189.7	3423.0	2073.9	3140.7

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