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Deliverable D3.7

Manuscript to a peer-reviewed journal on valuation of non-market effects (externalities) of aquaculture and capture fisheries activities

February 6th, 2019

Executive summary

This deliverable summarizes the work performed under task 3.5 "Assessment and valuation of non-market effects of aquaculture and capture fisheries", and formulates it in the form of a manuscript for publication in a peer-reviewed journal. The intended audience of the journal is researchers, analysts and policy makers. In order to report from this task in a language understandable for a broader audience, we below give a summary of the most important findings and main conclusions.

There is no doubt that the European production of fish generates huge economic values and provides important proteins to the world population. Still, it is not unreasonable to ask whether this industry, or the various industries involved in production of fish, also have environmental footprints, which are not accounted for.

We use two fish production activities to demonstrate typical effects on the physical environment caused by fish production. The two case studies are farmed Atlantic salmon and harvest of wild cod, and we used Scottish and Norwegian fish farmers and Icelandic and Canadian cod harvesters as empirical cases.

There is large agreement across both sector and nation that regulations are needed to secure sustainable fish production. Also, there is relatively large agreement that the current regulations are good in order to reach this goal. The only exception is Icelandic cod fishers, who are less satisfied with current regulations than are the other fish producers. Most respondents also agree that the regulations are easily accessible, but Norwegian producers of farmed salmon find it slightly more difficult to access the regulations.

Among producers of farmed salmon sea-bed and MTB (maximum total biomass) are the most important issues to secure sustainable activity, whereas green licenses and escapees are issues assessed as the least important. Among cod fishers, quotas and discards regulations are assessed as the most important to secure sustainable fisheries. Interestingly, all respondents think that producers are the agent most responsible for securing sustainable fish production. Salmon farmers also think producers' organizations are highly responsible, whereas cod fishers think national authorities are the second most important agents. All respondents agree that consumers and ENGOs are the lest responsible agents.

There is willingness to pay (WTP), in the form of higher production costs, to reach production alternatives with less negative environmental effects. Salmon farmers have high WTP for efforts to reduce Fish in – Fish out ratio (FIFO) and to achieve certification, and somewhat lower WTP for reducing the risk of sea-lice infestation of wild salmon and probability for accidents that cause escapees. Cod fishers have a positive WTP for reducing sea-bird mortality and to keep current regulations of discards, which allows them to discard fish below minimum size and non-commercial species, which are alive. They are not willing to pay to reduce the annual fluctuation in landings.

Fish producers of different sectors and nationalities are surprisingly consequent in their replies to questions regarding regulations to avoid or mitigate negative environmental effects of their activities. This yields a leeway for fisheries authorities to intervene and regulate fisheries activities.

Given the strong policy implications of the study Marine Policy was selected as the target journal. The manuscript was submitted to this journal on the 05.02.2019, and is currently under revision. Presented below is the paper as first submitted for publication in Marine Policy.

This paper acknowledges funding from the PrimeFish project.

Article as first submitted: Title Page and abstract

European fish producers' willingness to pay to reduce negative externalities of fish production

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Keywords: fish production, externalities, regulations, acceptance, responsibility, choice experiment

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Abstract

The existence of negative externalities is an argument for public intervention in the form of regulations of the production process. The production of fish is a sector with significant negative externalities, and correspondingly many regulations. The preferences of managers of production units are hardly elicited to inform the design of these regulations. This paper reports from an early study among various types of fish producers in various countries on how they assess current regulations of their activities, whether they are willing to accept increased production costs to reduce or mitigate the externalities, and who they think are responsible for securing sustainable fish production across Europe. We show that the respondents are surprisingly consequent in their replies to these questions, and that there is a leeway for fisheries authorities to intervene and regulate fisheries activities.

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1 Introduction

There is no doubt that the European production of fish generates huge economic values and provides important proteins to the world population. The contributions of aquaculture producers and capture fisheries are estimated from industry figures to be about 4 billion Euros and 7 billion Euros respectively in 2013 (see e.g. Bostock et al. 2016). Still, it is reasonable to ask whether this industry, or the various sectors of the industry, also have environmental footprints, which are not accounted for? In economics, an externality is an unintended positive or negative consequence of an economic activity experienced by unrelated third parties (Investopedia, 2019). The term reflects the fact that the production causes costs or benefits to society, which are not internalized, i.e. are not reflected in the costs or income of the agent.

Negative externalities are often associated with detrimental environmental effects of economic activities. Examples of negative externalities of European fish production is the killing of sea-birds by fish harvesting and the pollution of the sea-bed by fish farming. Fish production may also have positive externalities, like for example the integrated aquaculture - IMTA (Troell et al., 2003). While the outcome of the mentioned positive externality is captured by economic agents and thus internalized, negative externalities are seldom internalized voluntarily (Wiesmeth, 2012). For this reason, governmental regulations of fish production are formulated to incentivize or force fish producers to internalize negative externalities. Often, without such regulations, the production activities will cause too hard pressure on the ecosystems, which in turn will break down, and render further production impossible. Hence, it is in the fish producers' own interest that regulations are introduced. The reason why the producers don't individually internalize the destructive externalities to ensure their production is sustainable is the free rider situation. This means that producers addressing and internalizing the externalities will get a cost disadvantage, whereas all producers will enjoy improved production conditions.

In this study, we use various approaches to elicit the acceptance among European fish producers of a few present regulations aiming at reducing negative externalities. On one hand we ask fish producers how they assess current environmental regulations (i.e. regulations aiming at protecting the physical environment and marine ecosystems) and who are the most responsible agents for securing sustainable fish production. On the other hand, we use a choice experiment to elicit fish producers' willingness to pay, in the form of increased production costs, for production alternatives with less negative externalities. A willingness to accept higher production costs to ensure fewer negative externalities is interpreted as an acceptance of regulations aiming at reducing or mitigating such externalities. A combination of ascribing high responsibility for sustainable production activities to themselves, finding the current regulations acceptable and being willing to pay for production alternatives with less externalities thus indicates strong support for public intervention in the form of regulation to reduce or mitigate externalities in fish production.

Empirically, this study involves a few fish producers from salmon aquaculture and wild cod fisheries in three European countries. We implemented an online survey among producers of farmed salmon in Norway and Scotland, and cod fishers in Iceland and Norway. The four sub-samples are convenience samples rather than representative samples. Still, results from this study is of interest as it has been an early investigation into the use of choice experiments to elicit fish producers' concern for negative externalities and their willingness to pay to reduce or mitigate such externalities.

The paper proceeds as follows: Section 2 presents some background for the study. Section 3 presents the methodology. Section 4 presents results and section 5 discusses and concludes.

2 Choice experiments among fish producers

Choice experiments have previously been applied to elicit producers' preferences for various production related issues. While most of these studies are within agriculture, there are a few studies of fish producers. Within fisheries, Eggert and Martinsson (2004) elicited fishers' risk preferences. The survey asked fishers to make pairwise comparisons between a production alternative with low expected outcome and low risk and an alternative with higher expected outcome and higher risk. Altogether, six such comparisons were presented in the survey; the results showed that 48% of fishers could be characterized as risk neutral, whereas 26% were modestly risk-averse and another 26% strongly risk-averse. This was a postal survey sent to a sample of 600 units in the Swedish commercial fishing vessel register. This register contains names of either the owner of a fishing vessel or one of the owners of the company owning the vessel. Altogether 202 responses could be applied for analysis purposes.

Andersen et al. (2012) applied a choice experiment to analyze fishers' short-term selection of métier in the Danish gillnet fishery. Metier is the combination of fishing ground, gear and target assemblage. Commercial fishers in a mixed fishery make use of several decision variables, of which seasonal availability of individual target species and within-year changes in monthly catch ratio were the most important. Other important variables were information on the whole fishery, fish prices and distance travelled to fishing ground. The choice data applied was taken from a sub-sample of 54 gillnet fishers in a larger survey, which was distributed to 789 fishers in the Danish demersal fleet.

Wattage et al. (2005) implemented a choice experiment among various stakeholders belonging to the UK fishing fleet operating in the English Channel. The aim of the survey was to study different stakeholders' preferences for various aspects of three sets of management objectives (conservation, socio-economic, allocation). Among the 23 respondents in the study were managers of fishing companies, fishers, ENGO representatives and scientists. The results showed that the most preferred aspects of management were a combination of increasing yields, maintenance of regional employment and reducing conflicts between various gear types. The authors conclude that choice experiments are a useful approach for evaluating management alternatives and programs in the field of fisheries (op cit, p.93)

Turning to agriculture, Bond et al. (2011) elicit Colorado corn producers' preferences over both private and environmental public-good production system attributes. Positive preferences are found for farm profit, risk reduction and systems with lower environmental impact in terms of nitrate leaching and soil erosion. The highest utility comes from reducing the risk of losing half the crop, whereas increase in profit gave the lowest utility. The two environmental attributes, nitrate leakages and soil erosion, were preferred over profit increase, but below risk reduction. The authors emphasize that results from this kind of survey can be used by policy makers to predict behavioral responses associated with the introduction of new technologies. They can also be used to assess welfare implications of stricter environmental policy.

Another choice experiment within agriculture elicit Ethiopian farmers' preferences for crop variety (Asrat et al., 2010). They show that farmers are willing to forego some extra income or yield to obtain a more stable and environmentally adaptable crop variety. A total of 131 farmers were interviewed, and with each making 9 choices the sample encompassed 1179 observations.

So far, we have not come across any choice experiment among fish farmers.

3 Methods and materials

3.1 The survey instrument

A web-based survey encompassing questions concerning knowledge of and assessment of environmental regulations, and producer specific questions, was distributed to fish producers in three European countries. These questions were common across the two sectors and nationalities. The survey also encompassed a choice experiment, which differed across sector but was common for respondents within the same sector but of different nationality. While the assessment of environmental regulations, their importance, and stakeholder responsibility were measured on a Likert scale, running form 1 (low importance/ responsibility), to 6 (high importance/responsibility), the choice experiment was used to derive willingness to pay to reduce negative externalities in monetary terms.

Prior to the formulation of the surveys the literature was consulted, and interviews made with stakeholders within each industry. The interviews were made with Norwegian stakeholders and translated into English and Icelandic and shared with stakeholders within the Scottish farmed salmon industry and Icelandic cod fisheries. This input secured the inclusion of the most important and relevant externalities as attributes in the CEs.

Based on information on the most important externalities in each sector, 3-4 of these externalities were selected to be used in the CEs. The selected externalities were framed as attributes describing more sustainable production alternatives.

From the literature, salmon lice and accidents leading to escapees were identified as focal environmental issues in the salmon aquaculture industry (Svåsand et al., 2016). Other important issues are the fish in – fish out ratio (FIFO) and sustainability certification. The FIFO ratio refers to the amount of fish it takes to produce a defined unit of farmed salmon (Jackson, 2009). More sustainable salmon farming practices require a reduction in FIFO. The sustainability certification yields incentives for making production environmentally sustainable in general. There are various certification schemes available for salmon farmers, with ASC (Aquaculture Stewardship Council) as the most widely applied. Production costs excluding slaughter costs for salmon are at present GBP 3.20 and NOK 26.20 in Scotland and Norway respectively. These costs are increased by 2-20% as the attributes take better levels (externalities reduce).

Regarding harvesting of cod, the literature has established that sea birds get caught in the fishing gear and die by fisheries activities (Jackson, 2008; Žydelis et al., 2013). For some fisheries the rate has been quite high, up to 60% (Jackson, 2008). For others it is lower. Efforts may be taken to reduce this rate, and we assume these efforts can reduce the percentage of local seabird stocks that get caught in fishing nets to 40% or 20%. In Icelandic and Norwegian fisheries discards are in general prohibited, but exceptions exist for small fish that can survive and fish of non-commercial species that can survive. It is of interest to elicit if fishers prefer this leeway in the regulations, or if they would prefer a total ban of discards. Industries dependent on renewable natural resources by nature are fluctuating with respect to output, and in this survey, we are interested in knowing whether fishers prefer lower fluctuations in annual landings. This attribute is expected to express fishers' acceptance of outcome uncertainties, which is a type of risk. Present landing costs for the cod fisheries in Iceland is 88 ISK/kg and in Norway 103 NOK/kg. These costs are increased by 5-20% as the attributes take higher (better) levels. Figure 1B presents an example of a choice card in the cod survey.

The attributes and assigned levels are shown in table 1.

Table 1 Attributes and attribute levels for salmon survey

Attribute	SQ level	Level 1	Level 2	Level 3	Level 4	Level 5
Framed salmon						
Salmon lice induced mortality	30%	20%	10%			
FIFO	1.4	1.0	0.6	No		
Escapees	Every 7.year	Every 15. Year	Every 20.year			
Certification	No	Yes				
Prod.cost per kg., GBP/NOK	3.20/26.15 (current)	3.26/26.67	3.36/27.45	3.52/29.34	3.68/30.07	3.84/31.38
Wild cod						
Sea birds	60%	40%	20%			
Discards	As today	Totally banned				
Fluctuation in annual landings	As today	Lower than today				
Landing costs per kg, ISK/NOK	88/6.22 (as today)	93/6.57	98/6.93	103/7.27	108/7.63	

In both surveys, alternatives 1 and 2 represent production scenarios with improvement in at least one attribute level. These alternatives are combinations of the SQ attribute levels and level 1-5 in table 1. The alternative production scenarios were designed using the software Ngene and we used the D-error to choose the most efficient design (Kanninen, 2002). Figure 1A shows an example of a choice card from the salmon survey. The present situation

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(alternative 3) is described by a high probability (30%) for wild salmon to be infected by sea lice and die, a FIFO rate equal to 1.4, a probability for a major accident leading to escapees every 7 years, no certification and production costs equal to 26.20 NOK/3.20 GBP per kg (excluding slaughter costs). Figure 1B shows an example of a choice card from the cod survey. The present situation is described by a high probability for sea-birds to get caught in fishing nets, some possibilities for discards and large fluctuations in annual landings.

Figure 1A Example of choice card from the salmon survey

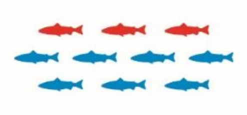
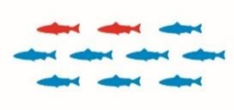
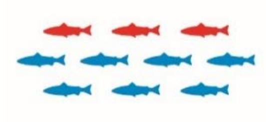
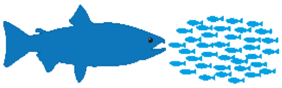
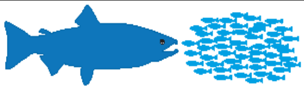
ATTRIBUTES	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3 (No further efforts taken)
Increased risk of sea-lice related death for wild migrating salmon	 30%	 20%	 30%
Fish in-fish out (FIFO) ratio	 FIFO is 1	 FIFO is 0.6	 FIFO is 1.4
Escapee accident	 About once in every 7 years	 About once in every 20 years	 About once in every 7 years
Sustainability certification	FARMED RESPONSIBLY asc CERTIFIED ASC-AQUA.ORG		
Production cost per kg fish	**29.34 NOK/kg**	**31.38 NOK/kg**	**25.15 NOK/kg**
Your preferred Alternative			

Figure 1B Example of choice card from the cod survey

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ATTRIBUTES	***ALTERNATIVE 1***	***ALTERNATIVE 2***	***ALTERNATIVE 3 (current situation)***
Reduction in local Seabird abundance	 40%	 20%	 60%
Discards	NO	YES	YES
Stability in cod landings	Unstable	Stable	Unstable
Increase in landing costs per kg harvest	Increase on 5 ISK/kg (to 93 IKS/kg)	Increase on 20 ISK/kg (to 108 ISK/kg)	No increase
Your preferred production alternative			

3.2 Data collection and samples

During autumn 2017 the salmon survey was distributed to all producers of farmed salmon in Norway and Scotland. Due to very low response rates, alternative procedures had to be applied to collect necessary data. This included calling up producers asking if they could be willing to participate in the survey. If they agreed, we sent the survey electronically to an e-mail address of the respondent's choice. Usually, the respondents filled in the survey electronically on their own, but in some cases, we assisted them over phone when filling in the survey. The cod survey among Norwegian fishers and fishing companies was implemented during autumn 2018. We used public registers of active fishing vessels on county level and extracted between 2-5 vessels from each of the 8 most important fishing counties. The vessels extracted were chosen based on vessel size and vessel age in order to secure representation of various size and age categories. In the register, companies owning the vessel are given including phone number of companies. We called up the company and asked whether if they would participate in the survey. If they accepted, we forwarded a link to the electronic survey. Altogether 35 companies were contacted. Of these, 21 accepted to participate in the survey and got the link to the electronic questionnaire. After 2 reminders, 13 of the companies had filled in the survey. In Iceland no public register of fishing vessels exists. Hence, we had to use alternative ways to select and approach relevant participants in the survey. After consultation with the Icelandic partner of the project, and in cooperation with a researcher from this partner, we approached fishers in various harbors and asked them to fill in a paper version of the survey. We implemented this procedure in 5 main fishing harbors on the west coast of Iceland during the first week of July 2018. Table 2 yields an overview of the four sub-samples.

Table 2 Sample size for four sub-samples, N=48

Farmed salmon			**Wild cod**		
	Population	Sample		Population	Sample
Norway	164	12 (2)*	Iceland	1065	12
Scotland	7	2 (6)*	Norway	1297	13
Total		14 (8)	total		25

*the first number indicate industry respondents and the number in parenthesis indicate respondents not directly working in the industry. Total number of respondents is the sum of the two.

The farmed salmon industry in Scotland is very concentrated, with only 7 independent companies. Two of these are multinational enterprises with Norwegian origin. Tough market conditions and a recent breakdown in the Scottish farmed salmon industry made it difficult to collect data from Scottish salmon farmers, and we only managed to have 2 companies responding to the survey. Hence, we supplemented this sample with a few stakeholders closely related to the farmed salmon industry. Among these were the leader of the producer organization, a veterinary, 2 technicians and 2 food scientists, all of which had been formerly employed in the Scottish farmed salmon industry. The population of 164 producers in the Norwegian farmed salmon industry is per 2016. There is an ongoing process of mergers and acquisitions taking place in the Norwegian farmed salmon industry, and the number of producers is likely to be smaller in 2017, when the data collection took place.

There are many individual fishers and smaller fishing companies trawling for cod both in Iceland and Norway. In the annual profitability survey of fishing vessels (Fisheries Directorate, 2017) the population of vessels harvesting cod is 1297, of which 840 are below 11 meter length. In Iceland we applied the publicly available data from Fiskistofa (www.fiskistofa.is/veidar) to select all vessels that during the year 2018 fished cod.

3.3 The random utility model (RUM)

The choice experiments (CE) encompassed 9 choice cards, and the formulation of the CEs are explained in section 4. Based on responses to the choice cards it is possible to derive monetary estimates for values attached to a set of attributes, which in both cases corresponded to a set of relevant externalities for the specific sector including the cost of internalizing these environmental externalities in the production process. We do this by using the random utility model (McFadden, 1973), assuming that the utility of production to a fish producer depends on a set of attributes (externalities) describing the production process, including production costs. To take into account the influence of random components on producer utility we also add an idiosyncratic error term, which is independent and identically distributed (i.i.d.). Hence, utility of a production alternative *j* to respondent *i* can be formulated as follows;

$$U_{ijt}(b|\,X) = b * X_{jt} + \epsilon_{ijt} \qquad (1)$$

where b is a vector of preference parameters to be estimated, X is a vector of attributes and ϵ is an i.i.d. distributed error term.

A utility maximizing agent is likely to chose alternative when $U_{ijt} > U_{ikt}, \forall k \neq j$. Hence, production alternative j is chosen by respondent i when $b(X_{jt} - X_{kt}) > (\epsilon_{kt} - \epsilon_{jt})$. When the error terms are extreme value distributed, we have that the right hand side of this inequality is logistically distributed.

With logistically distributed error terms the choice probability above is given as follows:

$$P_{ijt} = \frac{exp^{b'Xijt}}{\sum exp^{bXikt}} \qquad (2)$$

Equation (2) is the probability for respondent *i* to choose production alternative *j* in choice situation *t*. With T choice situations and N respondents, the aggregate probability for all observed choices is given by

$$L = \sum_{i=1}^{N} \sum_{t=1}^{T} P_{ijt}{}^{y} \qquad (3)$$

where y is a dummy taking the value 1 if alternative *j* was chosen by individual *i* in choice situation *t*, and 0 otherwise.

Taking the log of (3) yields the log likelihood function, which is maximized to yield estimates for the b-vector. This vector of estimates can be interpreted as marginal utilities for each of the attributes.

Dividing each non-cost attribute by the cost-attribute estimate we can interpret the resulting term as marginal willingness to pay (WTP) for a change in each of the non-cost attributes. Hence,

$$WTP_m = \frac{-b_m}{b_c} \quad (4)$$

where b_m is the estimate of a non-cost attribute and b_c is the estimate of the cost attribute. The main drawback of the basic multinomial logit model as we have specified above is the independence of irrelevant alternative (see Hensher et al., 2015; Train, 2009). However, since we are only interested in the actual behavior of fish producers, and not to use the model for forecasting, the basic MNL model as we have specified should suffice.

4. Results

4.1 Characteristics of the samples

The Norwegian sample of 12 producers of farmed salmon encompasses both small independent producers and subsidiaries of larger companies. The average number of production locations is just above 7, while the average number of licenses is just below 20. Half of the companies were established before 1990. Three quarter of the companies produce their own smolt, and half of the companies have some or only green licenses. Annual production ranges from 1500 tons to 60,000 tons. In addition to 12 fish farms the Norwegian sample encompasses 2 industry stakeholders; a representative of the producer organization (PO), and a scientist in fish biology formerly working in the industry. As there is only 2 Scottish producers in the sample, we cannot reveal any information about them.

Regarding cod fishers, the Norwegian sample of 13 producers encompasses both small independent vessels and vessels belonging to larger trawler companies. The average length of the vessel in the sample is 46 meter, and the average number of employees in the company is 81. Almost three quarter of the vessels are certified. In addition to cod, most of the vessels also catch saithe, pollock, halibut and catfish. The Icelandic sample encompasses somewhat smaller vessels, where the average length is 22 meters and the average number of employees is 40. One third of the vessels are certified. In addition to cod, most vessels also catch saithe, pollock and redfish, and two were catching sea cucumber.

4.2 Knowledge and assessment of environmental regulations

Both surveys started by asking how fishers and fish farmers assessed the regulations of their activities with respect to combat negative effects on the natural environment, and how accessible they find these regulations. Table 3 presents the results from these introductory questions.

Table 3 Assessment of environmental regulations and their accessibility, cod-fishers and producers of farmed salmon, number of responses, N=47

	Very good/good	OK	Very bad/bad	N

Cod fishers	Iceland	Norway	Iceland	Norway	Iceland	Norway	
Assessment	4	5	4	7	4	1	12/13
Accessibility	4	1	5	9	3	3	12/13
Salmon farmers	Scotland	Norway	Scotland	Norway	Scotland	Norway	
Assessment	5	9	2	4	1	1	8/14
Accessibility	5	7	2	5	1	2	8/14

While fish farmers largely agree that the current regulations are either very good, good or OK, about 20% of the cod fishers assess them as bad or very bad. These cod fishers are mainly from Iceland. Norwegian cod fishers assess the regulations as either very good, good or OK. There is no difference between Scottish and Norwegian fish farmers.

Focusing on accessibility, again it is the cod fishers who are more skeptical. One quarter of both Icelandic and Norwegian cod fishers regard the accessibility of the current regulations to be bad or very bad. Most fish farmers find the accessibility of the environmental regulations very good, good or OK, and this is true for both Scottish and Norwegian farmers.

4.3 Environmental issues

Which environmental issues are fish producers concerned about? For cod fishers we first listed a set of environmental and regulatory issues often associated with catch fisheries and asked the respondents to indicate those issues that according to them were important. Of the 12 issues listed, the respondents could tick off as many as they liked. There was also an open category "Other; please specify", but only one respondent filled in this category. Figure 2 yield responses from the total sample of cod fishers (25).

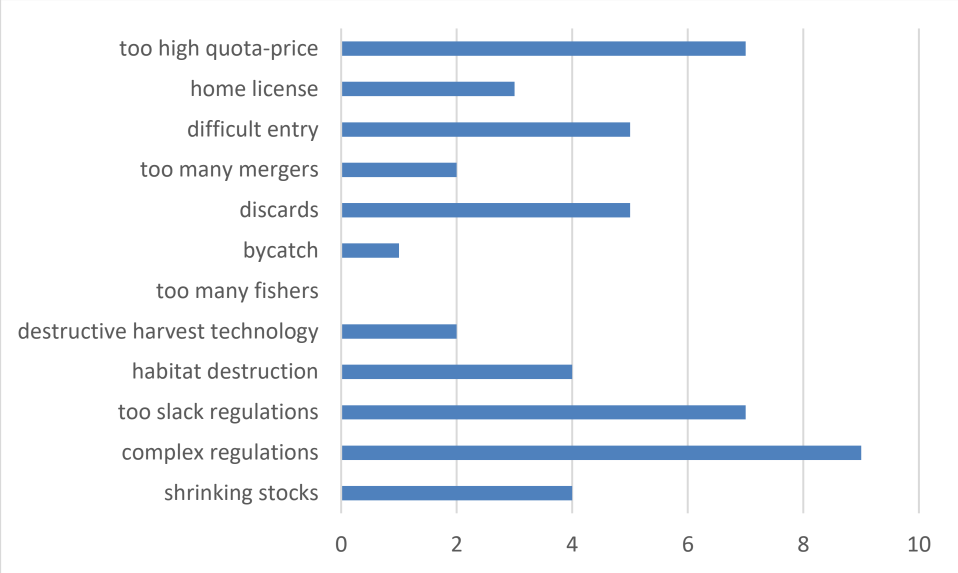


Figure 2 Most important environmental and regulatory issues within cod fisheries, number of respondents mentioning the issue, N=25

The two most frequently mentioned issues are "complex regulations" and "too slack regulations", which were mentioned by 36% and 28% of all respondents respectively. The third issue mentioned by relative many respondents are "too high quota prices". The most frequently mentioned environmental issue is "discards", mentioned by about 20% of the respondents, followed by "habitat destruction" and shrinking stocks". Nobody mentions "too many fishers" as an environmental or regulatory issue of concern.

There is an interesting difference between Norwegian and Icelandic respondents. While 55% of the Norwegian respondents mention "complex regulations" as an important issue, 50% of the Icelandic respondents mentioned "too slack regulations" as an important issue. The issue "too high quota prices" was mentioned by one third of the Icelandic respondents, but only 1-2 of the Norwegian respondents. For the other issues there were not significant differences between Icelandic and Norwegian fishers.

On a scale from 1 to 6, where 1 means not important and 6 means very important, respondents were asked to indicate how important they found a set of regulations to mitigate some of the environmental issues in figure 2a. Figure 3 yields responses from the total sample of cod fishers (25).

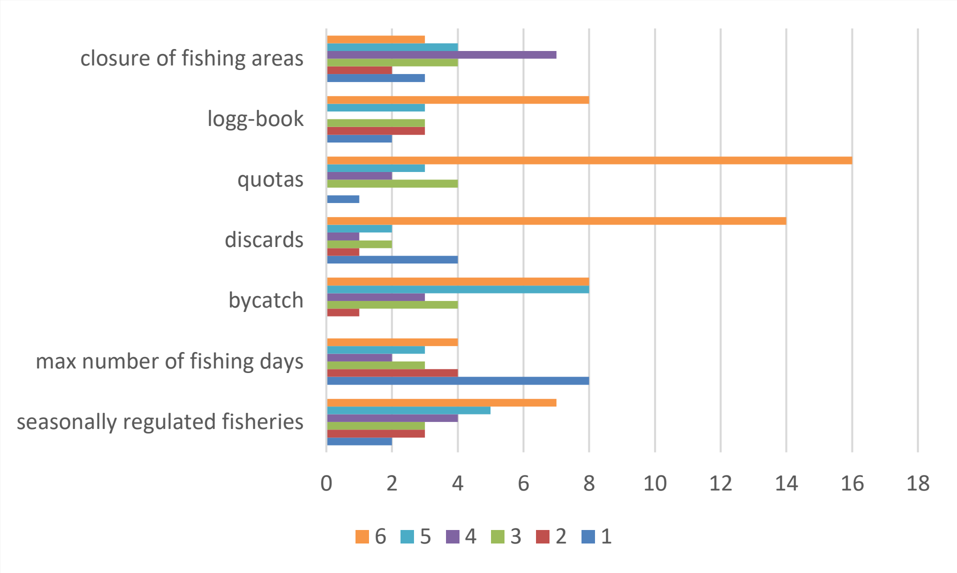


Figure 3 *Importance of selected regulations within cod fisheries, number of respondents*

Two regulations stand out; the quota regulations and discards. Then follows regulations of by-catches, whereas regulations of number of fishing days is considered of little importance, as is also seasonally regulated fisheries. There is little difference across Icelandic and Norwegian fishers when it comes to these assessments.

Turning to salmon farmers, they were asked, on a scale from 1-6, how important according to them each of six mentioned issues/regulations are. The scale was the same as for cod fishers. Figure 4 shows how salmon farmers asses the importance of each of the issues.

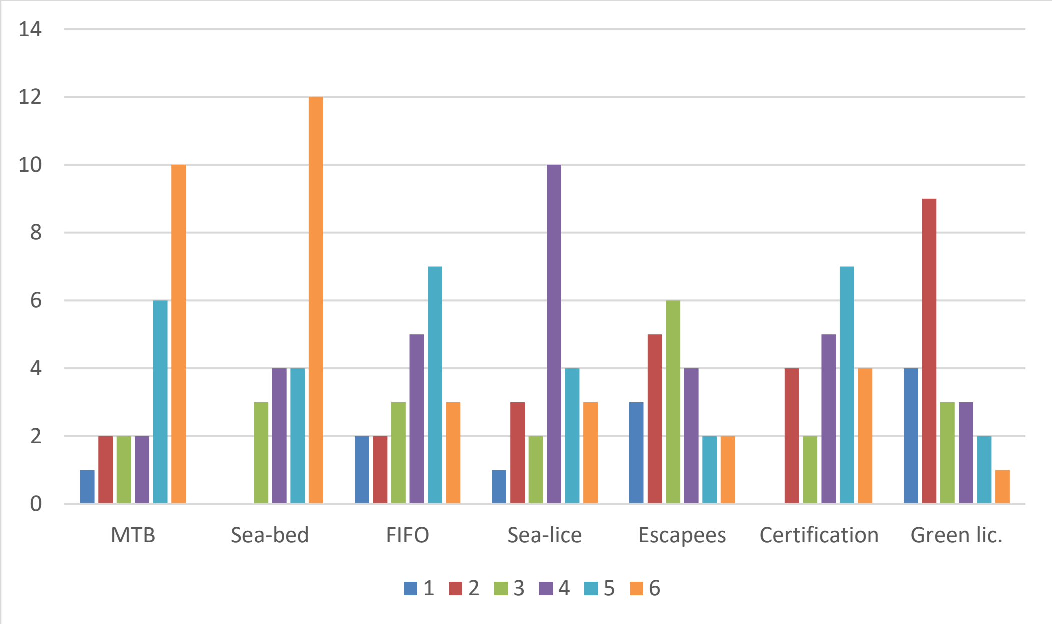


Figure 4 Importance of environmental and economic issues within salmon farming, number of respondents

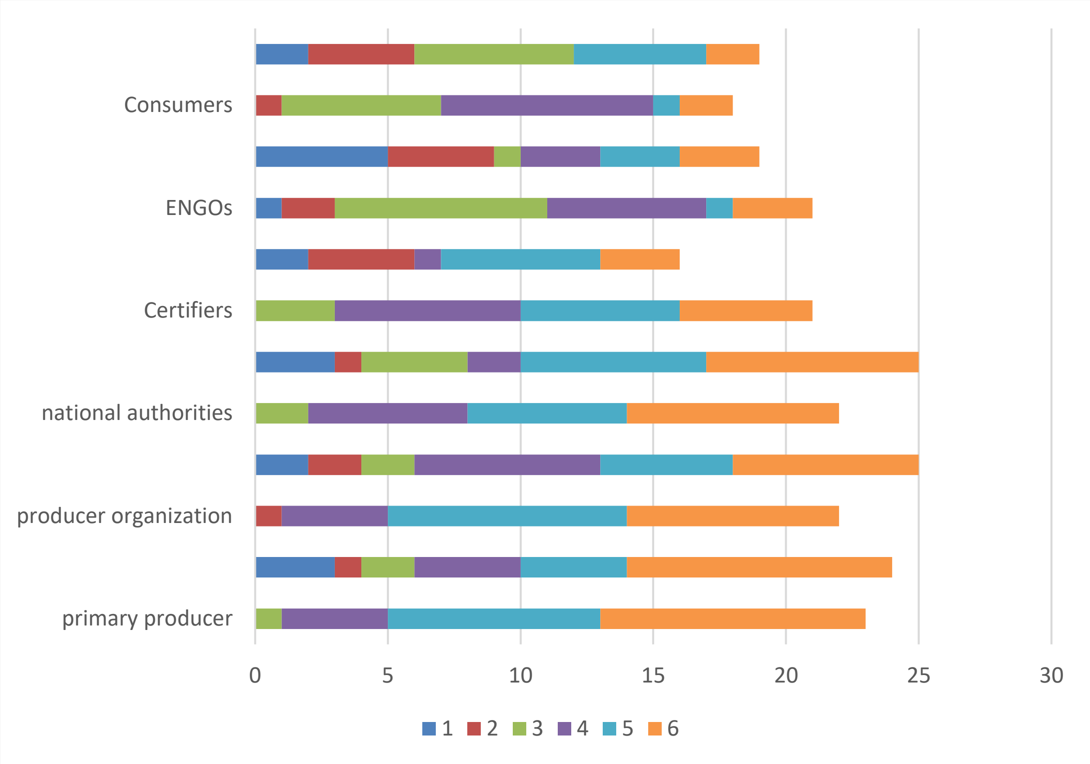
While sea-bed quality and MTB (maximum total biomass) are the most important issues/regulations for salmon farmers, the introduction of green licenses and problems with escapees are assessed as the least important. Certification is assessed as slightly more important than sea-lice and the FIFO rate. Note, however, that the importance of certification is more equally distributed across all importance levels, whereas FIFO and in particular sea-lice are peaking for importance levels 4 and 5 (medium to high importance).

There is an interesting difference between the Norwegian and the Scottish respondents. While the Scottish respondents consider the MTB regulation as the single most important issue, Norwegian respondents consider sea-bed regulations as most the important issue. Scottish fish farms (only 2!!) consider the FIFO-rate, sea-lice and certification as more important than sea-bed regulations. Escapees and green licenses are ranked the lowest of both Scottish and Norwegian respondents.

4.4 Who are the responsible agents?

We asked both salmon farmers and cod fishers how responsible are, according to them, various stakeholder groups when it comes to securing environmental sustainability of fish production? We applied the same scale as for the environmental-regulatory issues above. Figure 5 yields the results for salmon farmers and cod fishers respectively, where the lower bar represent farmed salmon producers and the upper bar represent cod fishers.

Table 5 How responsible are various stakeholder groups for sustainable fish production, lower bar = farmed salmon producers, upper bar = cod-fishers, number of respondents



Salmon farmers ascribe higher responsibility to producers and producers' organization compared to cod fishers. This can be seen from the fact that the aggregate of the green and blue part of the bars representing salmon producers, i.e. bar 1 and 3 from below, are larger than in the bars representing the cod fishers, i.e. bars 2 and 4 from below. The two sectors ascribe relatively equal responsibility to national authorities and certifiers, whereas cod fishers ascribe more responsibility to ENGOs and consumers compared to salmon farmers.

Looking at each sector individually, both sectors ascribe themselves, i.e. fisher/skipper, fishing company, fish farm, the highest responsibility. While fisheries authorities and the Government are ascribed high responsibility for sustainable cod fisheries, they are regarded as less important for sustainable fish farming. Producer organizations are seen as more important for sustainable production in aquaculture than in traditional fisheries. At the lower end, both sectors agree that ENGOs and consumers are the least responsible for securing sustainable fish production. Results for each sector individually can also be found in figures A1 and A2 in the appendix.

In the cod fisheries, Norwegian respondents ascribe the largest responsibility to the fisher/skipper while the Government is the second most responsible agent. For Icelandic fishers it is the vice versa. Hence, there is agreement across the two nationalities on who are the top two most important stakeholders, but not their internal ranking. There is also agreement across Norwegian and Icelandic respondents that consumer organizations and ENGOs are the two stakeholder groups least responsible for securing sustainable fisheries activities, but the order differ also here. While Icelandic respondents give ENGOs the lowest score, Norwegian respondents give consumer organizations the lowest score. Within farmed salmon production, there is no significant difference across Scottish and Norwegian respondents.

4.5 Willingness to pay for addressing environmental externalities in fish production

As part of the survey, respondents were asked fill in 9 choice cards (examples of the choice cards are given in Figure 1a and 1b). Based on choices of production alternative in the choice cards we can estimate the respondents' assessment of each of the environmental attributes, and in turn calculate a willingness-to-pay (WTP) in monetary terms for reducing or mitigating each of them. Table 6 yields the assessment of each attribute by salmon producers and cod fishers respectively (upper part), and WTP in monetary terms (lower part), including their 95% confidence intervals. CIs overlapping zero indicates that the WTP-estimate is insignificant at 5% level.

*Table 6 Respondents within the salmon farming industry's assessment of environmental attributes (externalities), mean coefficient (std.error), *, **, *** means significant at 10%, 5% and 1% level*

Attribute	Farmed salmon producers	Attribute	Cod fishers
ASC		**ASC**	0.17 (0.30)
Sea-lice	-0.0825 (0.013) ***	**Sea birds**	-1.46 (0.75) ***
FIFO	-1.75 (0.34) ***	**Discards**	0.59 (0.25) ***
Escapees	0.051 (0.018) ***	**Landings**	-0.003 (0.25)
Certification	1.25 (0.262) ***		
Cost	-0.25 (0.091) ***	**Cost**	-1.35 (0.31) ***
LL-value	-146.17	**LL-value**	-189.6
R-square	0.095	**R-square**	0.18
Observations	204	**Observations**	214
WTP sea-lice	-0.34 (-0.13, -0.55)	**WTP sea-birds**	-1.08 (-1.19, -0.97)
WTP FIFO	-7.1 (-2.9, -11.3)	**WTP discards**	0.44 (0.04, 0.84)

WTP escapees	0.21 (0.03, 0.39)	**WTP landings**	-0.002 (-0.38, 0.34)
WTP certification	5.09 (1.4, 8.8)		

The negative coefficient of the sea-lice attribute indicates that lower wild salmon smolt mortality is preferred to higher. The FIFO rate also has a negative sign, indicating that production alternatives with lower FIFO-rate are preferred to alternatives with higher FIFO rate. The escapee attribute takes higher values the more rarely accidents implying escapees happen. Hence, the positive sign of the coefficient means that rarer accidents leading to escapees is preferred. The positive sign of the coefficient for certification implies that agents prefer to certify the salmon production. The negative sign of the cost attribute implies that agents prefer production alternatives with lower production costs to alternatives with higher production costs. This is what we would expect by rational economic agents.

The sea-bird attribute indicates how large proportion of a local population may die due to fish harvesting, and the higher value the attribute takes the more sea-birds die. Hence, the negative sign of this attribute indicates that cod fishers prefer alternatives with lower sea-bird mortality. The discard attribute takes the value 1 if discards are allowed according to current rules and 0 if all discards are banned. The positive sign of the coefficient indicates that cod fishers prefer alternatives with the current discard regulations. These two attributes are significant. The landings attribute takes higher values the more fluctuation there are in landings for a single fisher over the years, and a negative sign indicates that fishers prefer alternatives with lower fluctuations in landings. However, the estimate is far from significant. Also the ASC (alternative specific constant) is statistically insignificant, indicating that there is no systematic bias towards the SQ alternative that can't be explained by the attributes. The cost attribute is negative and highly significant, indicating rational agents preferring lower to higher production costs.

The R-squared indicates the fit of the model, i.e. how much of the variation in choices can be explained by the attributes. The model fit on 0.1 for farmed salmon producers and 0.18 for cod fishers are low, but not unreasonably low for this type of model, which typically have R-square scores between 0.1-0.2 (Train, 2009).

The WTP estimates are all significant in the farmed salmon model. This means that farmed salmon respondents are prepared to accept higher production costs to have lower probability for infesting wild salmon, lower FIFO-rate, more rare accidents that lead to escapees and to be certified. Looking at the WTP amounts, the agents are willing to increase production costs by 0.335 NOK per kg (0.04 EUR) to reduce the risk for infestation of wild salmon (and cause wild salmon smolt mortality), and 0.21 NOK (0.02 EUR) per kg to reduce the probability for accidents that cause escapees. In addition, they are willing to increase production costs with 7.09 NOK (0.7 EUR) to reduce the FIFO-rate by on average 45%, i.e.

from 1.4 to 1 (30%) or from 1.4 to 0.6 (60%). Certification is a similar attribute, for which stakeholders are willing to increase production costs by 5.09 NOK (0.5 EUR).

The results above also hold if we estimate the model only for salmon producers (Scottish and Norwegian) (see table 1A in the appendix for these results). For other stakeholders, however, this is not the case. Here only the WTP for reduced FIFO rate is significantly different from zero. In particular, the cost attribute is not significant in the sub-sample of other stakeholders, which is to be expected as these respondents are not producers, and thus probably more concerned about other attribute than the production costs. Hence, while the model seems to be a good predictor for commercial salmon farmers' preferences when it comes to production attributes, it is relatively poor when it comes to explaining other stakeholders' preferences w.r.t. production attributes.

Looking at the WTP amounts for cod fishers, they are willing to increase landing costs by 1.1 NOK/kg to reduce the mortality of sea birds by 20%. Further, they are willing to increase landing costs by 0.44 NOK/kg to keep the current regulations of discards. Fishers are not willing to increase landing costs in order to secure lower fluctuations in annual landings.

Splitting up the respondents in two sub-samples, the model explains the choices made by Norwegian fishers better than choices made by Icelandic fishers (see table 1b in the appendix for these results). This can be seen from the fact that for the Norwegian sub-sample all attributes except the landing fluctuation attribute are significant, whereas in the Icelandic case only the sea-birds attribute is significant (at 10%-level). In addition, the Likelihood value is lower and the explanatory power (R-squared) is higher for the Norwegian subsample.

5. Discussion and Conclusions

Having argued that it is not individually rational for a single producer to internalize negative externalities, we have in this study explored whether individual producers are willing to consider negative externalities by accepting higher production costs. A positive WTP to reduce externalities can be interpreted as an acceptance of governmental regulations of production activities with externalities. To what degree this might be the case is tested by asking the fish producers how important they assess the regulations aimed at mitigating the externalities to be, and who are responsible stakeholder groups, including themselves, for securing sustainable fish production.

This type of triangulation can be used to test the validity of the choice experiment results, i.e. whether it is reasonable to assume that positive WTPs for the externalities attributes can be interpreted as acceptance of public regulations to mitigate externalities. If fish producers regard themselves as one of the stakeholders being responsible for sustainable fish production, then we would also expect them to be willing to pay to reduce negative externalities of their activities. This, however, depends on whether they regard the current regulations to reduce or mitigate the negative external effects, to be efficient. If this is not the case, they may still believe they are responsible for sustainable production activities, but they are not willing to pay because they do not think the current or suggested regulations will be efficient in reducing the externalities.

Our study shows that producers of farmed salmon has a relatively high willingness to pay to reduce negative external effects. They also ascribe themselves and their organizations (producer organizations) high responsibility for securing sustainable production. Finally, they find the regulations aiming at mitigating negative externalities of their production, such as sea-bed pollution and sea-lice infestation of wild salmon, important. This indicates internal consistency in responses across the three measures, and we would expect a high degree of acceptance among producers of farmed salmon for existing regulations aiming at reducing negative externalities of salmon farming.

Cod producers are also willing to pay to reduce negative external effects of their activities, in the form of reducing sea-bird mortality due to fish harvesting. In addition, they prefer to keep current regulations of discards, allowing discards of alive fish of non-commercial species and fish below minimum landing size, and are willing to pay to avoid stricter discard regulations aiming at abandoning all discards. The latter result is reflected in their view on current regulations, where discards where ranked the second highest of a set of regulations. We then interpret their ranking of the discard regulation as a preference for the current regulation. The WTP for reducing sea-bird mortality stands in contrast to their assessment of current regulations when it comes to reduce or mitigate externalities. Although they are willing to accept increased landing costs to reduce sea-bird mortality, they rank the issue "destructive harvest technology" among the lowest (see figure 2a). Only 2 respondents out of 25 mention this as an important issue in catch fisheries. This may contribute to cast some doubts on their willingness to pay for reduced sea-bird mortality. On the other hand, if we count sea-birds to the marine habitat, the issue "habitat destruction" is mentioned by 4 (out of 25) as an important issue, which lends slightly more support to the result that they are willing to pay to reduce sea-bird mortality. All cod fishers ascribe much responsibility to themselves for securing sustainable harvesting activities, although Icelandic fishers rank the government as the most important stakeholder to securing sustainable fishers' activities. This result supports the positive WTP for the sea-bird and discards attributes.

In a risk-perspective, both sea-lice infestation and escapees increase the farmers' risk of losing part of the production. According to Bond et al. (2011) farmers in Colorado, USA, ranked reductions in risk for loosing half of the crop first, before environmental issues and increased profit. Salmon farmers, at least in Norway, seem to prioritize otherwise. When asked to choose between various production alternatives, they seem to favor alternatives with low FIFO-rate and certified production above alternatives with lower probability of escapees and wild salmon infestation with sea-lice.[4] One reason may be that many salmon

[4] We assume a positive correlation between infestation by sea-lice of wild salmon and farmed salmon.

farmers doubt the possibility of reducing the sea-lice and escapee externalities at any significant rate. A survey among fishers (Eggert and Martinsson, 2004) conclude that Swedish fishers are either risk averse or risk neutral, meaning that they prefer production alternatives with lower expected income and high degree of certainty to alternatives with higher expected income and lower certainty. If investing in efforts to combat sea-lice and escapees is interpreted as increasing the certainty of the production, then salmon farmers are not first and foremost risk averse, as they do not prioritize such efforts above other efforts. The preferred efforts for salmon farmers are to reduce the FIFO-rate and to get certified, both of which may increase the profitability of the production as the former reduces costs and the latter increases the market price.

Neither cod fishers seem to display much risk aversion. Choosing among harvest alternatives, they showed little interest for alternatives that reduced the fluctuation in annual landings but prioritize alternatives that reduced sea-bird mortality and that keep the current regulations for discards. Alternatives with lower fluctuation in annual landings can be seen as the less risky over time. One could, however, argue that the reason why fishers did not choose alternatives with lower annual fluctuations in landings may be that they doubted that it would be possible, at least using governmental regulations. Hence, although respondents in our survey did not choose production alternatives that could be defined as involving less risk for losses or fluctuations in production, this need not be because they are not risk averse. With better attributes to display the risk component, we may have had different results.

This leads us to the shortcomings of our study. The results presented in this paper are based on a small sample size, both for producers of farmed salmon and cod fishers. Although triangulation was used to confirm or not the results of the study, it must be taken into consideration that there may be a larger variation in opinions and viewpoints in the population. As such, the presented results are not necessarily representative, neither for producers of farmed salmon nor for cod fishers. Still, they do give valid insights into priorities and assessments made by cod fishers and producers of farmed salmon regarding negative externalities, public regulations to reduce or mitigate externalities, and stakeholder responsibilities. One of the methods, choice experiment, is efficient in teasing out respondents' preferences for efforts to reduce negative externalities. This method does not directly ask whether agents are willing to take such efforts, but rather ask them to choose among various production alternatives, and where one, named status quo (SQ), is taking no efforts and thus inducing no extra costs upon the producers. Choosing other alternatives than the SQ indicates that agents are willing to take some efforts to reduce or mitigate externalities even if this means higher production costs. In the future, more such surveys should be implemented among producers of fish to elicit their willingness to pay to reduce negative externalities. Combined with questions regarding their assessment of current regulations and responsibilities, this will provide information to fisheries authorities about fishers' willingness to pay, and thus acceptance of efforts to reduce or mitigate specific externalities.

6. Acknowledgement

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8. Appendix

Figure A1 Responsibility of agents within the cod fisheries, number of respondents

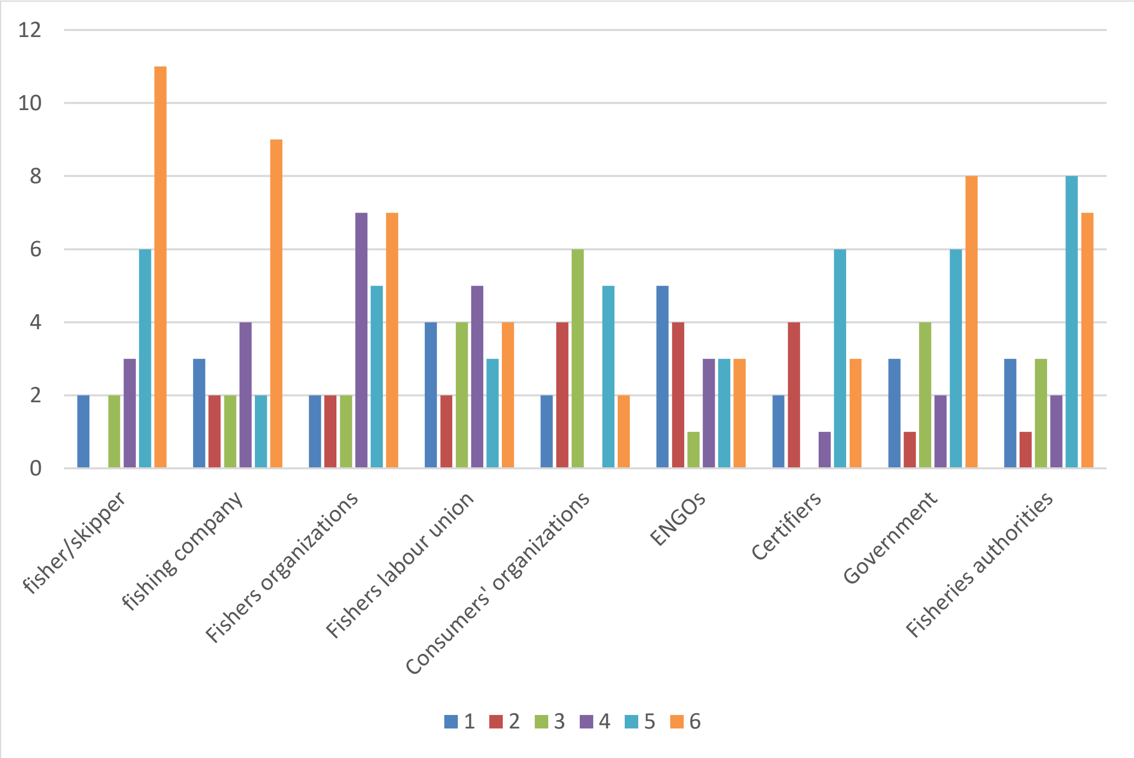

Figure A2 Responsibility of agents within the farmed salmon industry, number of respondents

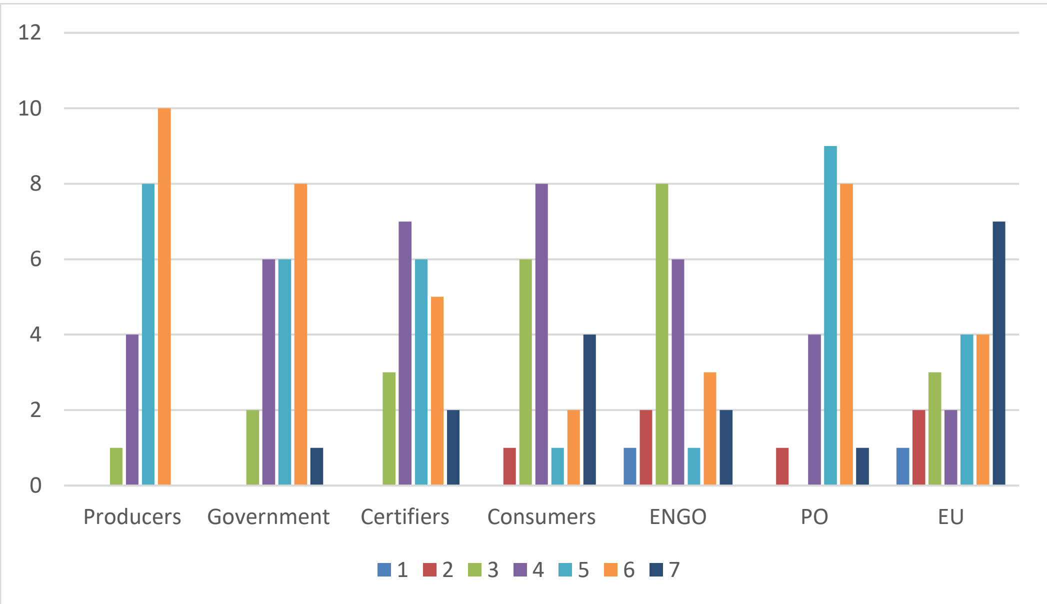

Table A1 Willingness-to-pay estimates in NOK (Norwegian kroner) and 95% confidence intervals for production attributes, all agents, producers and other stakeholders separately*

Attributes	Full sample		Producers		Other stakeholders	
	WTP	95% CI	WTP	95% CI	WTP	95% CI
Sea-lice	-0.335	(-0.55, -0.125)	-0.26	(-0.45, -0.06)	-0.44	(-0.89, 0.01)
FIFO	-7.09	(-11.3, -2.9)	-5.78	(-9.9, -1.7)	-9.1	(-17.5, -0.67)
Escapees	0.21	(0.03, 0.39)	0.32	(0.05, 0.6)	-0.07	(-0.32, 0.18)
Certification	5.09	(1.39, 8.8)	5.11	(1.07, 9.15)	4.1	(-1.56, 9.76)

*the exchange rate to Euro is just below 10 (9.68), hence by dividing by 10 the units are converted into Euro.

Table A2 Willingness-to-pay estimates in Norwegian kroner and 95% confidence intervals for production attributes. Icelandic and Norwegian fishers

Attributes	All		Norwegian		Icelandic	
	WTP	95% CI	WTP	95% CI	WTP	95% CI
Sea birds	-1.08	(-1.19, -0.97)	-1,165	(-3.83, 1.50)	-1.138	(-3.05, 0.78)
Discards	0.44	(0.04, 0.84)	0,634	(-0.36, 1.63)	0.0085	(-0.605, 0.62)
Landing fluctuations	-0.002	(-0.38, 0.34)	-0,064	(-0.75, 0.88)	-0.,106	(-0.76, 0.55)