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Attitudes towards the use of insect-derived materials in Scottish salmon feeds

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1 Attitudes towards the use of insect-derived materials in Scottish salmon feeds

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10 11 12 Abstract

13 Fishmeal is an important source of high quality protein in aquaculture, but concerns about its cost
14 and sustainability are making it a less attractive feed material. Replacing fishmeal with plant pro-
15 teins can impact on the nutritional quality of farmed salmon. In theory insect meals could be substi-
16 tuted for fishmeal without affecting the quality of the fish produced. They could also provide a way
17 of adding value to the bio-wastes used to rear the insects. However little is known about consumer
18 or producer attitudes towards the use of insect meals. This paper reports findings of a survey of
19 consumer attitudes in the UK, towards the incorporation of cultured insect larvae (maggots) - de-
20 rived feed materials into commercial formulated fish feeds for the Scottish Salmon farming sector.
21 It also investigates the attitudes of other stakeholders (salmon farmers, feed producers and fish re-
22 tailers) via semi-structured interviews. Consumer attitudes towards the use of insect meal were
23 found to be favourable (only 10% were opposed to the inclusion of insect meal in salmon feed
24 n=180), with vegetable waste being the preferred waste stream for rearing insects. The interviews
25 suggest that feed and salmon producers are in principle open to the use of insect meals, provided the
26 feeds are proven to be safe and reliable. However producing insect meal in sufficient quantity, qual-
27 ity and at a price that is competitive with existing feed materials will be challenging.

28
29 **Key words:** Aquaculture, Atlantic salmon, insect-meal, consumer research, Scotland.

30 31 32 1. Introduction

33
34 Aquaculture is now one of the fastest growing food sectors and plays an increasingly important role
35 in meeting global demand for fish (see Figure 1). However, successfully meeting future demand
36 will largely depend on the availability of quality feeds in requisite quantities. Commercial formulat-
37 ed feeds are key to the success and sustainability of future aquaculture systems for fin-fish and
38 shellfish – and in many cases accounting for 50-70% of the variable production costs depending on
39 farming intensity (World Fish Centre, 2009).

40
41 Farmed-fish require relatively high levels of protein in their diets, although they vary depending on
42 the species concerned. For instance carnivorous species such as the Atlantic salmon require much
43 higher levels of protein than omnivores such as *Tilapia* (Huntington and Hasan, 2009). In the de-
44 velopment of modern aquaculture, in the 1970s, fishmeal and fish oil were used as key feed ingre-
45 dients, supplying almost a perfect balance of the 40 or so essential nutrients required to ensure good
46 health and low feed conversion ratios (FCR). Generally, the fish meal/ fish oil component used in
47 aquaculture diets comes from whole fish caught for that purpose and by-catch and/or other low-
48 value species. FAO (2016, p46) report that 15.8Mt of fish (liveweight) was reduced to fishmeal and
49 oil in 2014, out of the total global fishery production (capture and aquaculture) of 167Mt.

50
51 Since demand for fishmeal from the aquaculture sector is growing faster than supply (OECD/FAO
52 2015), world fish meal prices of varying grades and qualities are expected to continue increasing. In

1 the last four decades, prices have increased fourfold (Seafish, 2014a). This rise reached a record of
 2 \$2,400 per t in 2014, mainly due to the sharp drop in anchovy catches in Peru - the world's largest
 3 exporter - caused by a rise in sea temperatures (Terazono, 2014). Hence in the next decade, the fish
 4 sector is expected to experience higher prices, but also higher production costs all in terms of fish-
 5 meal, fish oil and other feeds, and consequently of average farmed species (OECD, 2015)

6
 7 Owing to rising demand and prices, increasing volumes of fishmeal (by 2012 up to 35% of world
 8 fishmeal production) is being produced from previously discarded fish by-products (Seafish,
 9 2014b). Whilst this strategy offers clear benefits from a waste management perspective, it is also
 10 associated with drawbacks in the nutritional composition and quality of the resulting fishmeal. In
 11 general, such ingredients used in aquaculture then have more ash (minerals), an increased level of
 12 amino acids (such as glycine, proline, hydroxyproline) and less protein (Seafish, 2014b).

13
 14 Given the above, alternatives to fishmeal are being sought that will provide low feed conversion
 15 ratios, maintain acceptable fish welfare and produce foods that are tasty and nutritious. While fish
 16 meal and fish oil have excellent nutritional compositions, they are not necessarily essential ingredi-
 17 ents for a high quality fish feed, especially for non-carnivorous farmed species such as *Tilapia*. Oth-
 18 er combinations of terrestrial ingredients specific to each fish species may also achieve this balance.
 19 As a result, fishmeal content has been reduced in commercial aquaculture feeds from an average of
 20 23% in the 1990s to 10% by 2012 and replaced by sources from vegetable ingredients such as soy
 21 protein, corn and wheat gluten (CSF, 2014). However, most of those alternative protein sources
 22 compete with use for human consumption. In addition, they can alter the nutritional property of the
 23 final fish product, as they sometimes have unbalanced amino-acid profiles / omega-3 LC-PUFA,
 24 anti-nutritional factors and high fibre content. For this reason, other protein sources are required
 25 that create flexibility in diet formulation.

26 Insects reared on waste have been suggested as a potential alternative feed ingredient (Veldkamp et
 27 al., 2012; FAO, 2013). By reducing competition for plant protein, the use of protein derived from
 28 insects cultivated on low value organic wastes can represent a potential way of substituting digesti-
 29 ble protein in farmed fish feeds, whilst also reducing demand for fishmeal and adding value to low
 30 grade bio-waste streams. This is particularly relevant as recent estimates indicate that approximately
 31 one-third of food produced for human consumption is lost or wasted globally, amounting to about
 32 1.3 billion t every year (FAO, 2011). Considering this global waste challenge, the development of
 33 insect larvae-based feed ingredients can represent an opportunity to turn bio-waste into high quality
 34 saleable proteins. Those results however can vary with different production system methods, with
 35 fly larvae grown on a range of organic wastes being able to reduce the volume of that waste by up
 36 to 60% (PROteINSECT, n.d.). In comparison in a small-scale production facility in Ghana, insects
 37 reared on fruit waste can reduce their mass by up to 84% (Maquart, 2016). Table 1 shows the per-
 38 centage of waste reduction for different types of biodegradable waste.

39
 40 Table 1: Relation of studies of *Hermetia illucens* ability to convert different types of biodegradable
 41 waste into add-value products (Pastor et al. 2015)

Type of waste	Waste reduction (%)	References
Chicken manure	50	Sheppard <i>et al.</i> (1994)
Cow manure	79	Li <i>et al.</i> (2011a)
Municipal waste	68	Diener <i>et al.</i> (2011)
Coffee pulp	20	Lardé (1989, 1990)

Pig manure	28	Newton <i>et al.</i> (2005)
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Consumer attitudes towards fish reared on insect materials are critical to their success, however, there is currently little evidence on consumer attitudes. Verbeke *et al.* (2015) showed that 68% of the sampled farmers, agriculture sector stakeholders and citizens from Flanders were willing to accept the use of insects as an animal feed ingredient (although the sample size was small (n=82) and recruited at an agriculture fair, and thus may not reflect the attitudes of the wider population). Notwithstanding the sampling issues, the findings in Verbeke *et al.* (2015) are consistent with those in the EC funded PROteINSECT project, which surveyed over 1,300 respondents across 71 countries in the UK, EU and the Far East between October 2013 and March 2014. This benchmark survey was promoted via the PROteINSECT website, through social media channels including bloggers, and via appropriate e-zines and websites (Smith and Pryor, 2014). This sampling framework may also have introduced some bias, as it excludes significant demographics such as older individuals or lower income households who don't make use of internet. **Results showed that over 80% of consumers wanted to know more about using insects as feed, 52% were put off by the idea of eating insect-fed animal protein because they lacked sufficient knowledge on this topic, and 66% agreed that the larvae of flies are a suitable source of protein for animal feed (Undercurrent News, 2014; Reed Business Media, 2014).** According to the PROteINSECT project "people are more accepting of the idea of insects in food and feed than we might have predicted" (Smith, 2014).

Scope of the paper

Veldkamp *et al.* (2012) suggested mass production for insects for inclusion in commercial animal feeds may be considered realistic by 2017 (with expectation of uses in fish feed being closest to reality). However there is still limited data available on the magnitude, frequency, impact and perception of managed feeding of insects to farm animals (Byrne, 2015). This paper seeks to fill this gap by examining attitudes to the use of insect meal in Scottish Atlantic salmon production. It investigates the attitudes of (a) consumers and (b) key stakeholders (retailers, feed producers and salmon producers) to the use of insect materials in salmon feeds.

Relevance of the study setting

Scotland is currently the third largest producer of Atlantic salmon globally, and produced 179,022 MT in 2014 (Marine Scotland, 2015). Production has trebled over the last 20 years (see Figure 2). Over the years, concern has been expressed about the impact of fishmeal and fish oil use in the production of salmon feeds. In 2006, "the UK reported the highest usage of fish meal and fish oil within salmon feeds - 36% and 28%, respectively" (Tacon, 2008)." Since then the UK government has expressed a commitment to support industry-led sustainable aquaculture growth (DEFRA, 2014).

2. Methodology

2.1 Stakeholder Interviews

- Semi-structured interviews were undertaken with four industry stakeholders:
- a) A commercial-scale insect producer.
 - b) One of Scotland's main aqua-feed producers.
 - c) One of the world's largest farmed Atlantic salmon producers.
 - d) One of Scotland's biggest fish retailers.

The purpose of the interviews was to investigate stakeholders' awareness and knowledge of insect farming, and their attitudes towards the use of insect-derived materials in salmon feeds.

1 Each of the interviews were held by phone on a one-to-one basis, and lasted between 20 - 40
2 minutes . The telephone mode offered several advantages as it is typically less expensive and time-
3 consuming than face-to face in depth interviews. It does not suffer from geographic and other logis-
4 tical demands of bringing the interviewer and interviewee in the same location and was convenient
5 for scheduling a meeting (Roller and Lavrakas 2015). A semi-structured method was chosen be-
6 cause it allowed for both structure and flexibility, with discussions following their natural progres-
7 sion and varying according to spontaneous inputs raised by the interviewees. With the interviewee's
8 permission, the interviews were recorded then transcribed and analysed.

11 2.2 Consumer survey

12 Following the stakeholder interviews, a consumer survey (n=200) was undertaken in July and Au-
13 gust 2015 within the Edinburgh metropolitan area. The aim of the survey was to investigate (a) ur-
14 ban consumer's familiarity with current fishmeal composition and their perception of the challenges
15 faced by the aquaculture industry, and (b) attitudes towards the use of insects in fish feed.

16
17 Initial scoping was based on the findings of the stakeholder interviews, discussions with other re-
18 searchers. A draft questionnaire was designed and initial pilot testing was undertaken with two ran-
19 domly selected consumers. The questionnaire was revised and then a second stage of pilot testing
20 was undertaken with a further 20 consumers. The questionnaire was revised again in light of this.
21 The resulting questionnaire (see Appendix A) was divided into three sections, which collected in-
22 formation on:

- 23 1. Current fish purchasing decisions, knowledge of fish-farming practices and of fishmeal.
- 24 2. Attitudes towards the use of insects in feed, and the type of waste materials used for feeding
25 insects.
- 26 3. Demographic information.

27
28
29 The relevant survey population was identified using simple **random sampling methods**. To ensure
30 access to the attitudes and concerns of a broad range of societal groups, participants were recruited
31 at different times of the day in the above mentioned supermarkets. According to the Kantar World
32 Panel (2015), Tesco, Asda, and Sainsbury's hold respectively 28.6%, 16.5% and 16.5% of total
33 grocery market share in Great Britain; they were thus selected to recruit a representative sample of
34 participants (Kantar World Panel, 2015). Compensation included 20GBP- worth voucher for sea-
35 food products offered to two randomly selected participants. The final questionnaire was adminis-
36 tered by the same researcher to 200 participants face-to-face in different supermarkets and fishmon-
37 gers across Edinburgh.

38
39 A drop-off/pick-up method was used at the fishmongers but was associated with a low response
40 rate: 10 out of 40 surveys (with a target aimed at 20) were collected after two weeks. This number
41 was judged too small to provide rigorous and scientifically-sound results; and those surveys were
42 excluded.

43
44 Results were processed and analyzed using SPSS. For all performed analyses, the significance level
45 $P < 0.05$ was used as the threshold for statistical significance

48 3. Results

51 3.1 Stakeholder interviews

1 The information gathered from these interviews helped to adapt and refine the consumer surveys.
 2 Ultimately it also shaped an image of market demands and of potential hurdles insects could face in
 3 the fish-feed industry. (NEED couple more sentences here to summarize data)
 4

Table 2: Summary of stakeholder interviews key findings

Company profile	Attitudes and perceived challenges
Insect producer <ul style="list-style-type: none"> - US based company - 17 employees - Founded 2009 - Plant designed for six t of organic materials recycled by flies on daily basis - Selling into specialty markets 	<ul style="list-style-type: none"> - Company (as others) actively looking to expand (targeting production ~300t BSF larval meal by end 2015. May take 2-3 years to reach final target production level. - Safety is critical. This explains use of pre-consumer food waste as insect feed. - Best price for insect meal in bulk, frequently, can level at around USD 5.00 per pound. Today, ballpark numbers around USD 1300 per t. - Labour an important cost. Bigger plants and increased automation, utility/operational costs will reduce. Goal to be competitive - ultimately between fishmeal and poultry meal prices.
Aqua-feed producer <ul style="list-style-type: none"> - Headquarters Norway - 1,300 employees worldwide - Founded 1899 - Production around two million t feed for aquaculture species globally - Not a vertically integrated company, only produces complete feed 	<ul style="list-style-type: none"> - With demand and limited supply, fishmeal prices will only go up in future. - Fish meal not essential in fish diets, a protein source which can be replaced. - However industry can only use raw materials that are safe, approved by legislation and price competitive. - Insect larvae production: Technology currently limited to relatively small scale, commercial pilot set ups. - Existing large scale commercial aquaculture feed producers up to 600,000t production per annum in one country - Competition: Unless an additional value benefit for including insect meal in commercial diets found, it will not exist. - Perceptions: Although certain animal derived raw materials widely used in other countries, supermarket chains may not want risk of bad publicity or conversely can use to promote ecologically sustainable resource renewal
Fish Farming Producer <ul style="list-style-type: none"> - Headquarters Norway - 10,700 employees worldwide - Founded 2006 - One of largest global seafood companies Specialty: Atlantic salmon 	<ul style="list-style-type: none"> - Fish-farming industry relatively young compared to other food production sectors, plenty of space for development. - Currently only four major aquaculture feed producers globally, if one interested and willing to invest in insect production this increases chances of success. - Taste of farmed fish: Despite some variations in taste from different diets, fish reconstitute protein they eat from essential amino acids therefore insects in feed shouldn't have big impact on quality (or might improve taste for consumers). - Perceptions: Consumers generally won't have strong opinions on insect larvae used in fish feeds. As long as food is healthy, safe and contributes to reducing exploitation of wild fish stocks for fish meal consumers will be accepting.
Retailer <ul style="list-style-type: none"> - Headquarters UK - 476,000 employees worldwide - Founded 1919 - Multinational supermarket grocery and general merchandise retailer 	<ul style="list-style-type: none"> - Consumers increasingly interested in the provenance of their food. - Difficulty in communicating and informing through labels because consumers tend to get nervous with novelty. - Therefore if insects to be used in feed, neither insect nor type of waste would be included on label. - Retailers operate with customers at forefront of their sales strategy, protecting/informing them regularly in order to engender consumer trust and loyalty. - If preliminary research indicates positive consumer attitudes towards alternative more sustainable ingredients in farmed fish/livestock feeds, then retailers may conduct further customer-based surveys/ interactions to confirm consumer support.

1
2
3
4 **3.2 Consumer survey**

5 The following section reports results from the consumer survey regarding attitudes towards the use
6 of insects in fish feed, their perceived concerns and challenges.

7
8 The responses to questions 8, 9 and 10 indicate that consumers have limited knowledge of fishmeal
9 composition and the issues raised by its production (see Table 2).

10
11 Table 2: Consumer’s familiarity with current fishmeal composition and their perception of the chal-
12 lenges faced by the aquaculture industry.

Question	Yes (%)	No (%)	Number of responses
Q8. Do you think fish farming has any significant impact on the environment?	47%	53%	83
Q9. Farmed-fish are fed fishmeal. Do you know what it is made of?	22%	78%	39
Q10. Are you aware of any positive or negative issues arising from the production and use of fishmeal?	19%	81%	33

13
14 When asked “Would you eat farmed fish fed on an insect-based diet?” (Question 12) the responses
15 were in general favourable (see Figure 3). Most respondents were prepared to eat insect-fed fish
16 without having any concerns. Another 36% indicated they would be willing with reservations or
17 under certain conditions, for example that price, safety and taste would remain unchanged. Finally
18 10% were unwilling to eat insect-fed fish. Reasons cited included impacts on fish health (both posi-
19 tive and negative) and the belief that insects could provide “a more natural diet”. **Meanwhile others**
20 **participants believed insects were not a suitable feed ingredient.** The results imply some confusion
21 on the issues raised by insect materials, which may reflect a lack of knowledge on the subject.

22
23 When asked if they had heard of the possibility of replacing fishmeal with insect materials (at the
24 start of Section B) most respondents (91%) stated that they had not, however there does not seem to
25 be any difference in attitudes towards insect materials between individuals who were previously
26 aware of the concept and those who were not (see Figure 3).

27
28 **The results were analyzed to see if there were differences in attitudes between different social**
29 **groups (as defined by the UK National Statistics Socio-economic classification, Office for National**
30 **Statistics 2010).** However no statistically significant differences were found, perhaps reflecting the
31 small size of the sub-samples.

32
33 When asked which waste materials they thought were suitable for use as insect feed, most favoured
34 supermarket food waste and vegetable waste (see Figure 4), with a minority considering animal
35 manure, abattoir waste or human sewage suitable. This trend was the same for different genders,
36 age groups and occupations. When asked if the use of insect materials in the fish feed would affect
37 their willingness to pay for the fish, most (75%) respondents said it would not have an effect. How-
38 ever, this was for the inclusion of insects fed vegetable waste. Inclusion of insects reared on other
39 waste materials may have a more marked affect.

1 Finally, participants were asked two questions on their attitudes towards labelling. More than 80%
2 replied they would want the label to say whether the fish has been fed insects. In parallel, 67% said
3 they would want to know what type of waste the insect have been fed with.
4
5

6 **4. Discussion and conclusion**

7

8 The consumer survey indicated that most consumers would be willing to accept the use of insect
9 materials in farmed salmon, which is consistent with the findings in Verbeke et al. (2015). Both of
10 these studies are in contrast to the findings of the PROteINSECT project survey, in which 52%
11 were opposed to the inclusion of insect-derived feeds. It may be that because consumers tend to
12 know very little about feeds and their impact on the environment, they generally have no strong
13 opinions about the subject, and purchasing decisions are guided by other factors.
14

15 Taste was rated (amongst other factors) a very important indicator for purchasing decisions. Other
16 studies, such as Lock et al. (2014) indicate that fishmeal can be replaced with with insect meal
17 without impacts on taste, odour, or texture. **As a result, we may conclude here that taste, in itself,**
18 **will not be an obstacle to consumer's acceptance of insect-based feed.** The findings of this study
19 also suggest that price was not considered as important as taste or health benefits for influencing
20 purchasing decisions. However, insect and feed producing companies should be aware that most
21 seafood consumers were not willing to pay a higher price for insect-fed products.
22

23 Often data showed that more information (for instance through continued public engagement) could
24 increase awareness and likelihood that people will accept insect-based feeds. This is particularly the
25 case for people who are uninformed, or misinformed, about the benefits of insect-feed (for instance
26 regarding nutritional properties). Overall, **no cross-sectional differences across the cohorts over**
27 **time point in time** were found. In addition, findings showed that vegetable waste was the insect feed
28 preferred by consumers, though these preferences may change if different insect feedstocks lead to
29 different outcomes in terms of the price and quality of the fish. Finally, respondents indicated
30 wanting to know about insect-feed on their fish labels.
31

32 **In order to replace current protein sources in feed, insect producers will have to produce**
33 **large quantities of insect feed materials, of a high and consistent quality at a competitive**
34 **price.** Because most current insect larvae production companies have relatively low output, they
35 tend to go into specialty markets such as zoos and reptile feeds that seek a product with specific
36 nutritional profiles at a higher cost. However to access the aquaculture market, insect farmers will
37 need increased automation of their systems to feed regular schedules, increase production levels
38 and ultimately decrease labour costs. In addition, they will have to ramp up production and reach
39 quantities of insect biomass that are sufficient to satisfy the protein demand of feed producers. The
40 rate of expansion of this sector will depend, in part, on the attitudes of producers, retailers and con-
41 sumers as well on future changes in EU legislation.
42

43 The interviews suggested that, in principle, salmon producers would not be opposed to the use of
44 insect materials, provided they were traceable, safe, cost-competitive and did not impact on the
45 quality of their produce. The competitive and integrated nature of the salmon feed and farming sec-
46 tors means that uptake could be rapid, if and when insect materials started to be adopted.
47

48 At the moment the retail sector seems ambivalent, and would have to be confident of the market for
49 insect-fed salmon before embracing it. The findings from this study provide some grounds for op-
50 timism, as consumers attitudes towards the inclusion of insect in fish feed were found to be general-
51 ly favourable, with only about 10% of urban Edinburgh consumers opposed.

1 Currently, legislation represents a hurdle; with processed animal protein (PAP) being prohibited in
2 farmed animal feed (with the exception of hydrolysed proteins from non-ruminants in feed for non-
3 ruminants and non-ruminant PAP's in feed for aquaculture animals). Nevertheless, bans on the use
4 of insects in animal diets in the European Community are expected to be lifted in the near future.
5
6 However, in order to be successful, insect material will have to represent a practical, low risk, value
7 for money alternative to well-established feed materials. At present, cultivated insect materials ap-
8 pear to be not cost-competitive still compared to fish meals, but there may be considerable potential
9 for reducing the price by increasing the scale and efficiency of production. The development of
10 insect meals should be determined by the market, however, there may be a role for policy in remov-
11 ing regulatory barriers, improving consumer understanding and rewarding the social benefits of in-
12 sect meals such as: (a) reducing the costs of waste management by utilizing and recycling waste
13 streams, (b) reducing the social and environmental impacts of feed production and (c) increasing
14 food availability.
15

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2

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1 **Appendix A: CONSUMER SURVEY TEMPLATE**

2

3 **Consumer attitudes in Edinburgh towards inclusion of insect in aquaculture feeds**

4

5 **Questionnaire**

6

7 This short questionnaire is part of a project investigation being undertaken as part of my MSc. The
8 overall aim of the project is to investigate people's knowledge of, and attitudes towards, the use of
9 insects as feed in fish farming. It is an important part of the project, and I would therefore be very
10 grateful if you could take 10 minutes or so to complete and return it.

11

12 If you are unable to answer all the questions, please complete it as far as you can. When completed,
13 please either e-mail or post the questionnaire to us (contact details are given below).

14

15 You can enter our prize competition by sending us your contact details via email. Two winners will
16 be chosen randomly and offered a £20 voucher each to use at a fishmonger in the city.

17

18 If you have any queries about this survey, or would like to find out more about the project, please
19 feel free to get in touch.

20

21 Marine Popoff
22 SRUC
23 King's Building's
24 Edinburgh EH9 3JG

25

26 e-mail: marinepopoff@gmail.com

27

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41

1 **Section A**

- 2
- 3 1. In an average month, how often do you eat finfish and/or shellfish? (either as the main compo-
- 4 nent of a meal, or a fish-derived product)
- 5 0 1 - 2 3 - 4 5 - 6 7 - 8 9 - 10 11 or more
- 6
- 7 2. Please circle if you buy most often FARMED-RAISED or WILD CAUGHT fish
- 8
- 9 3. Can you explain why (in one word)?
- 10
- 11
- 12 4. What species do you eat most often?
- 13
- 14 5. How important are the following factors in influencing your decision when purchasing fish?

Health benefits	(Low) 1 - 2 - 3 - 4 - 5 (High)
Taste	(Low) 1 - 2 - 3 - 4 - 5 (High)
Easyness to prepare	(Low) 1 - 2 - 3 - 4 - 5 (High)
Price	(Low) 1 - 2 - 3 - 4 - 5 (High)
Sustainability ratings (eg. certification)	(Low) 1 - 2 - 3 - 4 - 5 (High)
Produced in Scotland	(Low) 1 - 2 - 3 - 4 - 5 (High)
Other (state).....	(Low) 1 - 2 - 3 - 4 - 5 (High)

- 16
- 17
- 18
- 19 6. Do you usually look for products that are categorised or have been certificated sustainable?
- 20 If so, please can you give specific examples: Yes No
- 21
- 22
- 23 7. Do you ask the person selling you the fish - in supermarket or elsewhere:
- 24 1. Where the fish come from ? Yes No
- 25 2. Whether they have been farmed or not ? Yes
- 26 No
- 27 3. If you do ask does the salesperson know to answer these questions? Yes
- 28 No
- 29
- 30
- 31 8. Do you think fish farming has any significant impact on the environment? Yes
- 32 No
- 33 If so, please state: I don't know
- 34
- 35
- 36 9. Farmed-fish are fed fishmeal. Do you know what it is made of? Yes No
- 37
- 38 10. Are you aware of any positive or negative issues arising from the production and use of fish-
- 39 meal? If so, please state: Yes No

1 **Section B**

2
3 With a growing population and concerns about fish stocks, the aquaculture industry has become
4 an increasingly important source of fish. Aquaculture uses fishmeal that is partially made of
5 species (such as eels) that are captured specifically for this purpose. In order to make the indus-
6 try more sustainable, it has been suggested that fishmeal in Scotland could be partly replaced
7 with feed materials derived from insects.
8

9 11. Had you heard this suggestion before ? Yes No

10
11 12. Would you eat farmed-fish fed on an insect-based diet?

Yes, because.....

Yes but

Maybe, if.....

No, because

12 13.

13 13. Insects for aquaculture feed can be raised on a range of waste materials. Tick the waste ma-
14 terials you think are suitable to be used

- 15 Vegetable waste
- 16 Food waste from supermarkets
- 17 Animal manure
- 18 Abattoir waste
- 19 Human sewage
- 20 All of the above
- 21 I don't know
- 22

23
24 14. Please circle your willingness to pay for product B:

25		
26	Fish A	Fish B
27	Fed on current fishmeal	Fed partly with insects (which have been fed vegetable waste)
28	Price X	Price: LESS / EQUAL / MORE
29		How much more / less?:
30		

31
32 15. Should labels state whether or not fish have been fed insect-meal? Yes /No /Don't know

33
34
35 16. Should labels state the type of wastes fed to insects? Yes /No /Don't know

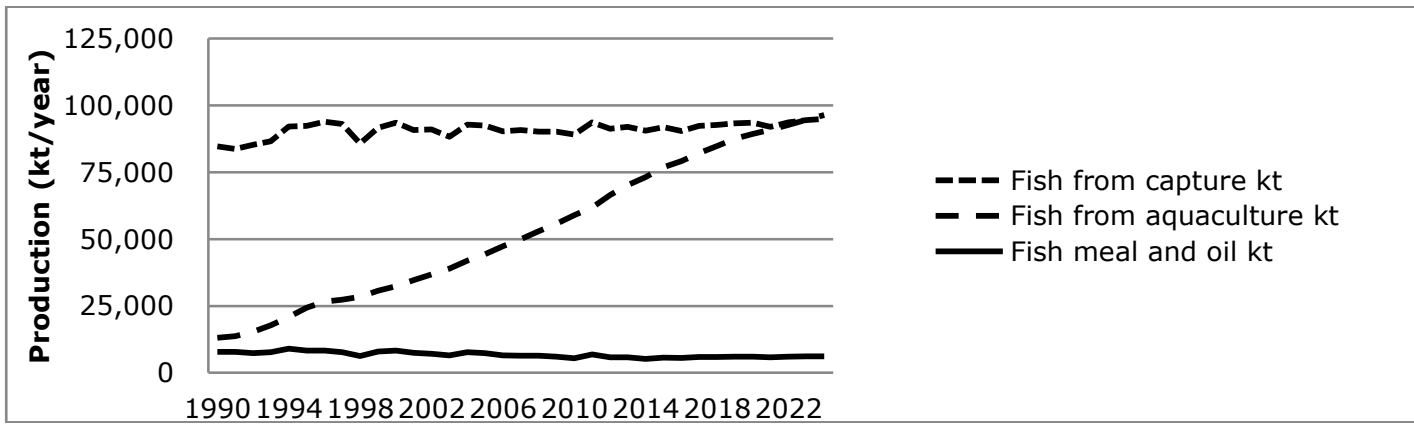
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38 17. Do you have any other comments?..... (Next page)

39 **Section C**

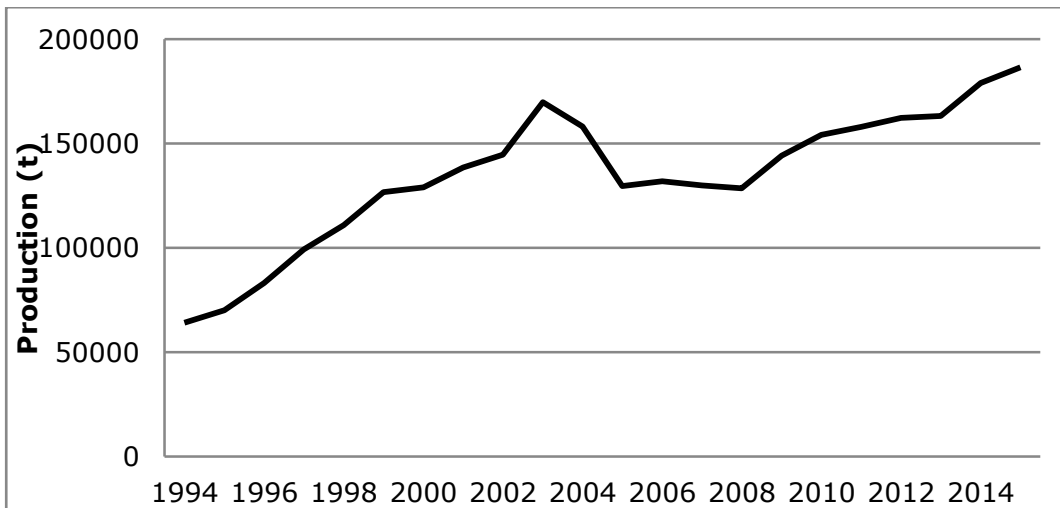
40
41 I. What is your age
42 0 - 20 21 - 35 36 - 50 51 - 65 66 +

- 1
2
3 II. Gender
4 Male Female Other
5
6
7 III. Are you working presently?
8 No Yes: state your profession Student Retired
9
10
11 IV. Do you have any children?
12 Yes No
13

1 **Figures**



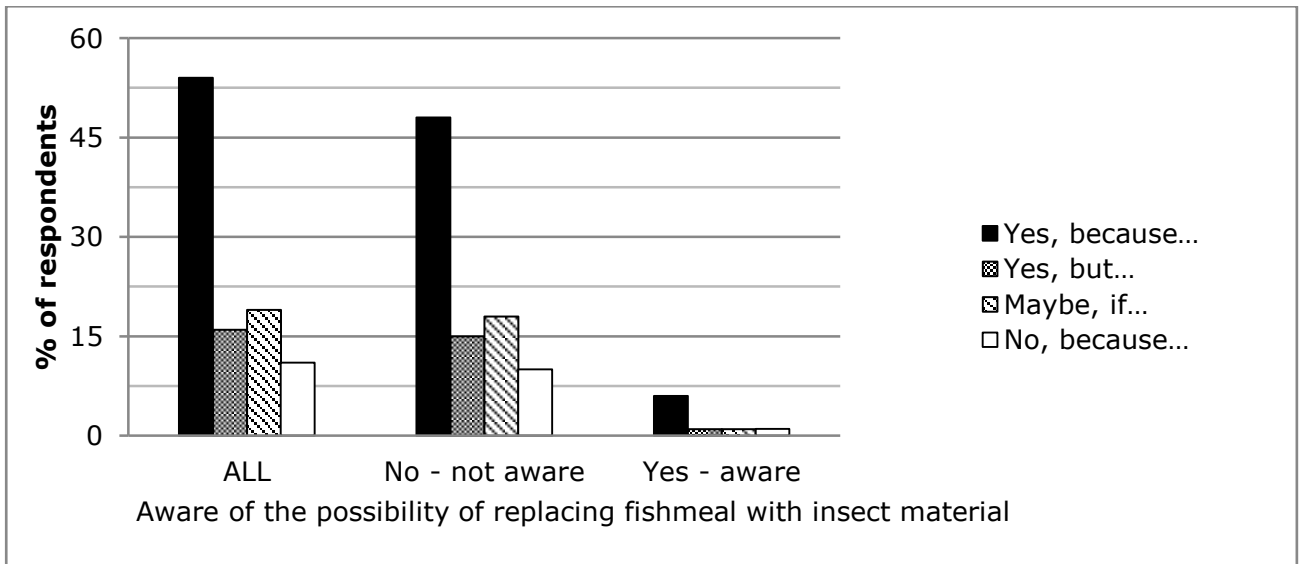
6 Figure 1. World production of fish (LW), fishmeal and oil.
7 Data extracted from OECD Stat, OECD-FAO Agricultural Outlook 2015-2024, 25/5/16



13 Figure 2. Farmed Atlantic salmon production in Scotland (data from Marine Scotland 2015)

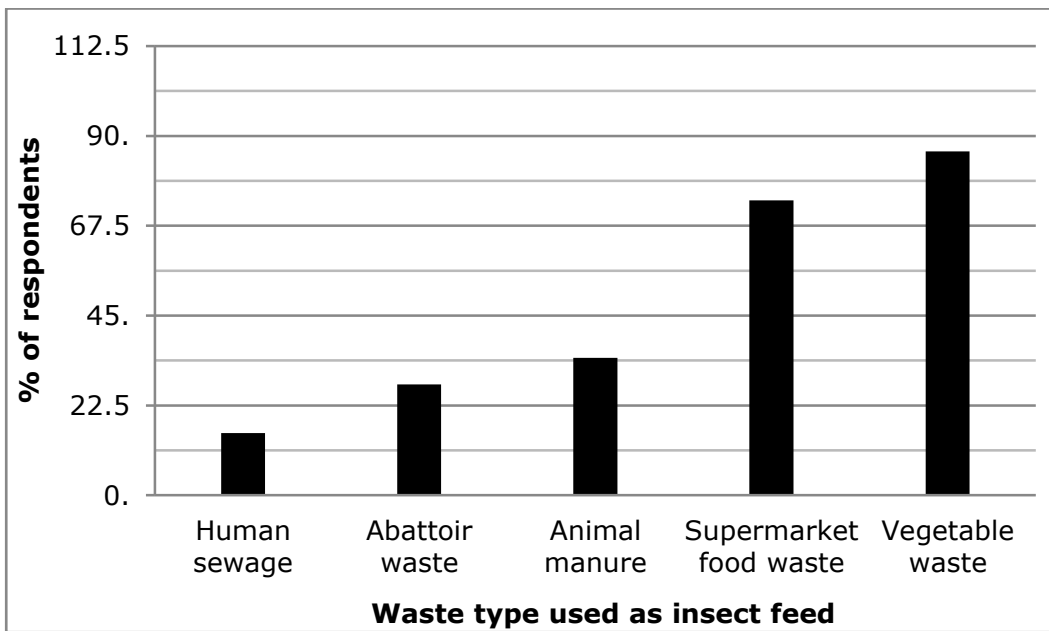
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Figure 3. Responses to Question 12 “Would you eat farmed fish fed on an insect based diet?”. The results are reported for two groups of respondents: those that had heard of the possibility of replacing fishmeal with insect materials (“Yes – aware”), and those that had not (“No – not aware”). (n=180)



10
11
12
13

Figure 4. % of respondents that considered waste materials suitable for using as insect feed. (n=180)