

- 1 **Title:**
- 2 A systematic review and analysis of long-term growth trials on the effect of diet on omega-3 fatty acid
- 3 levels in the fillet tissue of post-smolt Atlantic salmon
- 4
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Accepted refereed manuscript of:

Mock TS, Francis DS, Drumm DW, Versace VL, Glencross BD, Smullen RP, Jago MK & Turchini GM (2020) A systematic review and analysis of long-term growth trials on the effect of diet on omega-3 fatty acid levels in the fillet tissue of post-smolt Atlantic salmon. *Aquaculture*, 516, Art. No.: 734643.

DOI: <https://doi.org/10.1016/j.aquaculture.2019.734643>

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11 **Abstract**

12

13 Elucidating the specific effects of diet on the fatty acid composition in Atlantic salmon (*Salmo salar*),  
14 particularly health beneficial omega-3 long-chain polyunsaturated fatty acids (n-3 LC PUFA), remains  
15 an area of intense commercial interest given the increasing market restrictions placed on the supply  
16 of fishmeal and fish oil. The present study conducted a systematic review and subsequent analysis of  
17 published nutritional data from long-term growth trials using post-smolt Atlantic salmon to provide a  
18 summary of currently available information and to identify the most significant drivers of omega-3  
19 levels on Atlantic salmon fillet tissue. Overall, there were relatively few studies which met the  
20 selection criteria and this had implications for further explanation of some results. Statistically  
21 significant regression models were generated for fillet DHA and fillet n-3 LC PUFA. Fish weight was a  
22 significant predictor in both models, and dietary 22:6n-3 (DHA) was an intuitive predictor of fillet DHA.  
23 Furthermore, dietary EPA and dietary 22:1 isomers were significant predictors of fillet n-3 LC PUFA.

24

25 **Keywords:**

26 Atlantic salmon, omega-3, modelling, systematic review, nutrition

## 27 1. Introduction

28

29 The Atlantic salmon (*Salmo salar*) aquaculture industry is constantly balancing the expectation of  
30 producing fish with high levels of health promoting omega-3 long-chain polyunsaturated fatty acids  
31 (n-3 LC PUFA) whilst relying on dietary ingredients which are subject to intense market volatility  
32 (Oglend 2013; Sprague et al. 2016; Troell et al. 2014; Turchini et al. 2009). Therefore, the continuous  
33 evolution of dietary lipid and fatty acid compositions in aquafeed formulations is often influenced by  
34 the need of balancing both the fish's and consumer's nutritional requirements, coupled the  
35 fluctuations in cost and availability of dietary oil sources (Bendiksen et al. 2011; Hardy 2010; Sprague  
36 et al. 2016; Tacon & Metian 2015). A major trend in recent years has been the increasing level of  
37 substitution of marine derived oil sources, such as fish oil, with more readily available oils of terrestrial  
38 origin (Bendiksen et al. 2011; Sprague et al. 2016; Tacon & Metian 2015; Turchini et al. 2010). Whilst  
39 this has enabled the continual growth of the Atlantic salmon industry, it has resulted in compromises  
40 in product quality, and specifically in the reduction in the level of n-3 LC PUFA deposited in the fillet  
41 (Henriques et al. 2014; Nichols et al. 2014; Sprague et al. 2016). In order to further develop nutritional  
42 solutions to enhance the viability of Atlantic salmon aquaculture both industry and academia routinely  
43 engage in experimental dietary growth trials. Within industry, these trials are essential to the uptake  
44 of more cost-effective and sustainable aquafeed formulations, yet much of the quantitative data  
45 remains in-house and rarely makes its way to peer-reviewed academic journals (Henriksson et al.  
46 2012). On the other hand, despite significant research interest in Atlantic salmon, university and  
47 research and development provider-based experiments are often subject to financial and logistical  
48 limitations, including facility availability and the high cost of lengthy trials. However, from a biological  
49 perspective, confidence in recorded nutritional data is reliant on the assimilation of dietary fatty acids  
50 into fillet tissues, which are both time and growth dependent (Jobling 2003; Jobling 2004). In response,  
51 Rosenlund et al. (2016) advocated for a greater representation of long-term growth trials in the  
52 published literature to better elucidate n-3 LC PUFA utilisation in Atlantic salmon. Complicating this

53 endeavour, methods in data reporting often vary between research groups leading to inconsistencies  
54 when attempting to evaluate relevant quantitative data (Sales & Glencross 2011). The outcome is few  
55 attempts to collate and quantify published nutritional information on Atlantic salmon (Collins et al.  
56 2013; Sales & Glencross 2011).

57

58 A potential strategy to quantify the dietary effects on fillet n-3 LC PUFA in Atlantic salmon reported in  
59 published literature is via meta-analytic methods. Such methods are used to combine information  
60 from multiple studies to more accurately, and at the same time more broadly, evaluate or estimate  
61 an overall effect (Tweedie 2001). Analyses of this kind have traditionally been popular in the  
62 sociological and medical sciences and they are more recently being utilised as an effective quantitative  
63 tool to measure outcomes in numerous disciplines, including fish nutrition (Collins et al. 2013; Sales &  
64 Glencross 2011; Tweedie 2001). Specifically, Sales and Glencross (2011) quantified the effects of fish  
65 oil substitution on growth performance and fatty acid composition in Atlantic salmon. However,  
66 despite elucidating relationships between vegetable oils and fish performance, further extrapolation  
67 of results was hindered by a lack of uniformity and replication in the collected numerical data (Sales  
68 & Glencross 2011). Therefore, additional effort is required to identify the major drivers of fillet n-3 LC  
69 PUFA in post-smolt Atlantic salmon and also to assess whether a lack of published information is  
70 prohibitive to a robust discussion and interpretation of these drivers.

71

72 The objective of the present study was to utilise existing published data from long-term growth trials  
73 to i) summarise the extent of published information regarding long-term nutritional growth trials  
74 conducted on Atlantic salmon in seawater, and where possible, ii) describe the most significant drivers  
75 of fillet n-3 LC PUFA in seawater-reared Atlantic salmon. This was achieved by means of a systematic  
76 review and the subsequent analyses of the extracted data via meta-regression techniques.

77

78 **2. Material and Methods**

79

## 80 2.1 Systematic review

81 A systematic review of the literature was conducted to identify published studies that reported viable  
82 data for inclusion in the meta-analysis. The majority of literature was identified by entering two search  
83 terms 1) “Atlantic salmon fatty acid growth” and 2) “Salmo salar fatty acid growth” into the database  
84 ‘Web of Science’ with a time constraint of studies published post 1950. Manual searching techniques  
85 such as scanning of reference lists and broad searches using Google Scholar® supplemented database  
86 searching were used to retrieve more studies. Articles obtained from database searching ( $n = 1133$ )  
87 were added to articles obtained from manual searching techniques ( $n = 50$ ) (Figure 1). Initial screening  
88 of titles and abstracts removed duplicates and studies not using the target species. The remaining  
89 articles ( $n = 254$ ) were subject to full text assessments against the pre-determined eligibility criteria  
90 listed below.

- 91 a) Lipid proximate composition of feed must be reported
- 92 b) Lipid proximate composition of fillet must be reported
- 93 c) Fish must be post-smolt and reared in saltwater (not juvenile)
- 94 d) Fish must have had an increased weight of a minimum of 300%

95

96 The selection criteria above were agreed upon by a panel comprised of all co-authors and additional  
97 staff at Deakin University, and aimed at identifying only studies that would provide reliable, relevant  
98 data for the meta-analysis. Following methods described in Sales & Glencross (2011), only peer-  
99 reviewed works published in English were considered. Data was extracted from studies meeting the  
100 pre-determined selection criteria and included: i) growth, feed efficiency and biometric data, ii) dietary  
101 and fillet proximate composition iii) dietary and fillet fatty acid composition and iv) physio-chemical  
102 parameters. Where the same growth trial data was presented in multiple studies, the study best  
103 meeting the selection criteria or with the most complete dataset was included. Within studies,  
104 individual treatment groups that did not meet all requirements of the selection criteria were omitted

105 from inclusion in the database. To accommodate for changes to dietary proximate composition  
106 concomitant with increasing fish size within treatments, where necessary, the dietary proximate  
107 composition was reported as the average fed to experimental fish based on the percentage of total fish  
108 growth at each dietary proximate composition level.

109

## 110 *2.2 Unit conversion*

111 All fatty acid data used in the present study was converted to mg g<sup>-1</sup> of diet and mg 100g<sup>-1</sup> fillet for diet  
112 and fillet fatty acid data, respectively. Due to a large number of studies reporting fatty acid data as a  
113 percentage of total fatty acids, two separate conversion factors were applied to the data. Based on  
114 studies by Emery et al. (2014) and Norambuena et al. (2015) a conversion factor of 0.76678 was applied  
115 to dietary fatty acid data reported in percentage of fatty acids to convert to mg g<sup>-1</sup> lipid. Similarly, based  
116 on studies by Emery et al. (2014) and Wilke et al. (2015) a conversion factor of 0.78831 was used to  
117 convert fillet fatty acid data reported in % of fatty acids to mg g<sup>-1</sup> lipid. Finally, diet and fillet proximate  
118 data was used to make the final conversion in order to report all fatty acid data as mg g<sup>-1</sup> diet and mg  
119 100g<sup>-1</sup> fillet.

120

## 121 *2.3 Data analysis*

122 Although the present study has combined multiple studies and analysed the resultant data, it is not,  
123 strictly, a meta-analysis as it did not measure outcome variables in response to a common control.  
124 Whereas dietary fish oil percentage has been used as a control in a meta-analysis by Sales & Glencross  
125 (2011), the present study focussed on the entire suite of dietary variables collected as predictors.

126

### 127 *2.3.4 Identification of collinearity*

128 Initially, 63 variables, each with up to 85 data points, were sorted into independent (36) and  
129 dependent (27) sets, then de-identified to avoid any bias in the analysis. Variables with fewer than 40  
130 data points were removed from the analysis; these were regarded as not having enough data to

131 contribute to analyses involving four or more variables. Collinearity amongst independent variables  
132 was checked by an exploration of a correlation matrix (Figure 2). Subsequently, a directed graph of  
133 variables with common  $R^2 \geq 0.9$  was obtained and collapsed according to principles of least missing  
134 data and fewest remaining nodes, resulting in twenty-six independent variables. Three pairs had fewer  
135 than 40 shared data points, resulting in 23 dependent variables. Histograms of each variable were  
136 checked for normality by fitting with both normal and lognormal curves.

137

### 138 *2.3.5 Principal component analysis*

139 Initially, an attempt to reduce the multidimensional space of the independent variables was made by  
140 standardising each variable and using principal component analysis (PCA), imputing missing data via  
141 the alternating least squares (ALS) algorithm. Histograms of the original and consequent datasets  
142 sometimes showed spurious imputation at either negative or large values. In most cases, but not all  
143 with respect to larger values, log-normal transformation of data eliminated negative values.  
144 Probabilistic PCA (PPCA) was trialled, but exhibited similar issues. Attempts to not impute data were  
145 confounded by a large number and distribution of missing data, resulting in fewer than 40 data points  
146 covering all variables, which, did not meet the threshold for reasonable multidimensional modelling.  
147 Similar issues occurred when repeating the processes over the dependent variable set. Hence, a  
148 reduction in dimensionalities via PCA was abandoned as an initial step.

149

### 150 *2.3.6 Multiple step-wise regression analysis*

151 Stepwise linear regression was then separately applied to the independent variables for two  
152 dependent variables of particular interest: fillet 22:6n-3 (DHA, docosahexaenoic acid) and n-3 LC  
153 PUFA. However, this process included variables of little practical significance including variables which  
154 violated distribution assumptions.

155 Therefore, the eight methodological and categorical variables were removed, leaving 18 purely  
156 experimental variables. Stepwise regression was again performed for fillet DHA and n-3 LC PUFA.  
157 Statistically significant models with three and five independent variables were created for fillet DHA  
158 and fillet n-3 LC PUFA, respectively. PCA with ALS over these identified variables again gave spurious  
159 values for imputed data, so basic PCA was carried out over the points with data for all variables (Figure  
160 3).

161  
162 In both cases, the three variables with the largest contributions to explaining the overall dataset  
163 variance were identified, and multiple regressions for each dependent variable of interest were  
164 performed (Figures 4 and 5). These figures show multiple perspectives on the three-dimensional  
165 spaces mapped by the remaining independent variables. Colour is used to indicate both the target  
166 dependent variable values and their estimation by the regression models.

167

### 168 **3. Results**

169

170 The systematic review resulted in the full text assessment of 254 peer reviewed articles, of which 15  
171 passed the pre-determined selection criteria (Figure 1). The studies included consisted of a variety of  
172 farm and laboratory-based studies. A brief summary of the relevant data extracted from the selected  
173 studies is presented below.

174

#### 175 *3.1 Water temperature, feed intake and biometry*

176 A summary of experimental water temperature, feed intake and biometry measures are presented in  
177 Table 1. The studies consisted of a variety of on-farm and laboratory-based trials and where reported,  
178 water temperature was given as temperature range or average or both (Table 1). The average water  
179 temperature combining studies was 10.9 °C. Final weights of fish ranged from 342 g to 3833 g, in



180 studies by Bell et al. (2001) and Rosenlund et al. (2016) respectively, and the average combining  
181 studies was 2001 g. The average food conversion ratio combining studies was 1.1.

182

### 183 *3.2 Diet fish oil percentage, proximate composition and fatty acid composition*

184 A summary of fish oil percentage, proximate composition and protein: energy ratios is presented in  
185 Table 2. Fish oil (expressed as percentage of added oil) varied from 0 to 100 % and averaged 37.6 %.  
186 Dietary protein and lipid (expressed as mg g<sup>-1</sup> diet) averaged 438.3 and 303.2, respectively. Dietary  
187 fatty acid composition of the 85 dietary treatments was expectedly varied (Table 3). Saturated fatty  
188 acid (SFA) content ranged from 20.9 to 101.8 mg g<sup>-1</sup> diet, presented in Torstensen et al. (2004) and  
189 Bell et al. (2002), respectively, and averaged 46.3 mg g<sup>-1</sup> diet across all dietary treatments. The level  
190 of dietary n-3 PUFA also varied amongst studies, concomitant with individual experimental aims.  
191 Dietary 18:3n-3 (ALA,  $\alpha$ -linolenic acid) levels ranged from negligible amounts to in excess of 100 mg g<sup>-1</sup>  
192 <sup>1</sup>, yet the average across all treatments was 23.9 mg g<sup>-1</sup> diets. Levels of both 20:5n-3 (EPA,  
193 eicosapentaenoic acid) and DHA varied, consistent with fish oil inclusion level, and averaged 10.1 and  
194 10.8 mg g diet<sup>-1</sup> respectively. The sum of n-3 LC PUFA ranged from 3.8 to 59.1 mg g<sup>-1</sup> diet in dietary  
195 treatments presented in Torstensen et al. (2005) and Friesen et al. (2015), respectively. The mean  
196 dietary n-3 LC PUFA level was 21.9 mg g<sup>-1</sup> diet.

197

### 198 *3.3 Fillet proximate and fatty acid composition*

199 In line with the selection criteria, all studies included reported the lipid proximate composition of the  
200 fillet and ranged from 37.7 to 165 mg g<sup>-1</sup> fillet tissue across the 85 treatments (Table 4). As expected,  
201 fillet fatty acid composition varied considerably among the 85 dietary treatments. Average fillet SFA  
202 content was 1443.8 mg 100g<sup>-1</sup> fillet and ranged from 595.1 to 2540 mg 100g<sup>-1</sup> fillet tissue in treatments  
203 presented in Bell et al. (2001) and Rosenlund et al. (2001), respectively. Reporting of individual  
204 monounsaturated fatty acids (MUFA) was often incomplete and, as such, the sum of MUFA was not  
205 included in the dataset. The predominant fatty acid 18:1n-9 was generally reported and ranged from

206 650.8 to 3804.5 mg 100g<sup>-1</sup> fillet tissue. Fillet levels of 22:1 (isomers not differentiated) were also  
207 consistently reported, averaging 318.0 mg 100g<sup>-1</sup> fillet tissue and showed large variation between  
208 treatments, ranging from 18.9 to 1488.2 mg 100g<sup>-1</sup> fillet tissue in treatment groups reported in Friesen  
209 et al. (2015) and Torstensen et al. (2001), respectively. Consistent with their relative importance in  
210 nutritional growth trials, n-3 PUFA was consistently reported and varied in accordance with dietary  
211 inclusion levels. Fillet levels of DHA (in terms of mg 100g<sup>-1</sup> fillet tissue) ranged from 198.0 to 1332.1 in  
212 Bell et al. (2004) and Bell et al. (2010), respectively, and averaged 514.0 across all 85 dietary  
213 treatments. The sum of n-3 LC PUFA was not always reported and, where necessary, was taken as the  
214 sum of EPA + DPA + DHA (where DPA is 22:5n-3, docosapentaenoic acid). Fillet levels averaged 850.2  
215 and ranged from 303.2 and 2216.7 mg 100g<sup>-1</sup> fillet tissue in treatments presented in Bell et al. (2002)  
216 and Bell et al. (2010), respectively.

217

### 218 *3.4 Modelling of fillet DHA and n-3 LC PUFA*

219 Step-wise multiple regression analysis was used to model both DHA and n-3 LC PUFA. Statistically  
220 significant models for both fillet DHA and fillet n-3 LC PUFA were created using the three independent  
221 variables with the largest contributions to explaining the overall dataset variance. For both fillet DHA  
222 and fillet n-3 LC PUFA, final weight as an independent variable explained a large amount of the total  
223 variance (Figure 3). The independent variables used to predict fillet DHA were: i) final weight, ii) diet  
224 ALA and iii) diet DHA (Figure 4). The independent variables used to predict fillet n-3 LC PUFA were: i)  
225 final weight, ii) diet 22:1, and iii) diet EPA (Figure 5). The resulting models were as follows:

226

227 1) Fillet DHA = (5.48) + (-0.001053 × final weight) + (-0.016158 × diet ALA) + (0.39596 × diet DHA);

228  $R^2 = 0.96854$ ;  $F = 646.6061$ ;  $p = 3.0028 \times 10^{-47}$

229

230 2) Fillet n-3 LC PUFA = (-90.3347) + (0.14154 × final weight) + (9.615 × diet 22:1) + (47.752 ×  
231 diet EPA)

232  $R^2 = 0.85066$ ;  $F = 119.6209$ ;  $p = 5.7426 \times 10^{-26}$

233

234 The three-dimensional models used highlight the variability in relationships between the independent  
235 and the dependent variables. Although for both models, particularly fillet DHA, the coefficient of  
236 determination ( $R^2$ ) values indicated the data fitted well with the regression field.

237

#### 238 **4. Discussion**

239

240 The first and most salient finding of the present study is that there is a paucity of industry-derived,  
241 peer-reviewed, published data from long-term growth trials conducted in seawater. This is despite the  
242 recognition of the continued resource volatility affecting dietary formulations in Atlantic salmon  
243 aquafeed, and the considerable amount of research effort that has been focussing on elucidating the  
244 impacts on fillet nutritional quality, especially levels of n-3 LC PUFA. The authors assert this is a current  
245 limitation to the uptake of more efficient aquafeed formulations necessary to ensure the long-term  
246 viability of the aquaculture sector.

247

248 It has been demonstrated that long-term growth trials are needed to ensure the effects of dietary lipid  
249 manipulation are accurately reflected in the fillet tissue of post-smolt Atlantic salmon (Rosenlund et  
250 al. 2016; Sissener et al. 2016b). With respect to the present study, an extensive search of peer  
251 reviewed literature, including the full-text assessment of 254 published articles, uncovered only 15  
252 studies with recorded nutritional data in post-smolt Atlantic salmon experiencing > 300 % growth on  
253 a single experimental diet during the growth trial period. Shorter trials may risk type II error, via an  
254 incomplete 'dilution' of the pre-trial fatty acid composition, hence, partially obscuring the actual  
255 influence of the administered dietary treatment (Jobling 2003). Additionally, ontogenetic change  
256 concurrent with a seawater life stage in Atlantic salmon affects fatty acid uptake and metabolism  
257 (Tocher 2010). Therefore, an enhanced focus on post-smolt Atlantic salmon subject to relatively long  
258 growth periods is warranted in order to maximise the commercial relevance of available nutritional

259 data. It is recognised that long-term growth trials in seawater are logistically constrictive to research  
260 groups due to high costs and scarcity of suitable trial facility infrastructure. However, these limitations  
261 can be, at least partially ameliorated with, or overcome by, successful industry collaboration allowing  
262 access to on-farm facilities that complement the necessary analytical capabilities typically available in  
263 research institutions (Hardy 1999; Perkmann & Walsh 2007). Hence, the present study advocates the  
264 continued progression of strong industry-academia partnerships within the aquaculture sector.

265

266 Despite a limited dataset, a robust statistical approach was implemented in order to minimise multi-  
267 collinearity within the resultant models. Consequently, statistical integrity was prioritised in order to  
268 confidently discuss the biological relevance of the resultant models. Final weight was a significant  
269 predictor for both fillet DHA and fillet n-3 LC PUFA. Although counterintuitive as a 'predictor', the final  
270 weight of a fish is often pre-determined in both a commercial and laboratory setting (Dunham 2011;  
271 Glencross et al. 2014). As such, final weight should be considered a controllable input variable for the  
272 purpose of the present discussion. Given the highly variable final weights in the dataset, final weight  
273 was responsible for a large amount of the variance within the dataset and therefore, unsurprisingly,  
274 was identified by PCA. From a biological perspective, relationships between fish size and fillet  
275 proximate composition, including, lipid level are known to exist in many species, including Atlantic  
276 salmon (Einen & Roem 1997; Kaufman et al. 2007; Salam & Davies 1994; Shearer et al. 1994; Shearer  
277 1994). Specifically, fish size is often positively correlated with fillet lipid composition (Shearer et al.  
278 1994). Given fillet fatty acid composition in the present study is reported in mg 100g<sup>-1</sup> fillet – the  
279 ultimate goal from a consumer nutritional information viewpoint – dietary lipid level and by extension  
280 final weight would be expected to have a positive relationship with fillet DHA and n-3 LC PUFA.  
281 Furthermore, dietary n-3 LC PUFA has been reported as essential to optimal growth in seawater reared  
282 Atlantic salmon (Hixson et al. 2017; Rosenlund et al. 2016). Despite this, final weight was both  
283 negatively and positively correlated with fillet DHA and fillet n-3 LC PUFA, respectively. The dataset  
284 was limited with respect to the reporting of final weight and often only a single figure was reported

285 as an experiment mean across dietary treatments. Therefore, despite a change in other independent  
286 variables, such as fillet proximate and fatty acid compositions within a study, final weight was  
287 sometimes clustered at a single value. Consequently, further extrapolation of the biological  
288 relationship between final weight and fillet DHA and n-3 LC PUFA composition is required.

289

290 Dietary DHA was positively correlated with fillet DHA as is intuitive, given the well reported 'mirroring'  
291 effect between dietary and fillet fatty acids, and in particular even more so for DHA itself (Bendiksen  
292 et al. 2011; Sales & Glencross 2011; Tocher 2015; Turchini et al. 2009). Dietary DHA is, indeed,  
293 generally unaffected by factors which can obscure or further modulate this mirroring effect, such as  
294 preferential  $\beta$ -oxidation and is, therefore well conserved (Bell et al. 2003; Bransden et al. 2003; Francis  
295 & Turchini 2017; Mourente et al. 2005; Pratoomyot et al. 2010). Finally, with respect to the fillet DHA  
296 model, dietary ALA was negatively correlated with fillet DHA, and this was somewhat unexpected and  
297 counterintuitive. In contrast to dietary DHA, dietary ALA is readily  $\beta$ -oxidised by salmonids (Bell et al.  
298 2001; Mourente et al. 2005; Stubhaug et al. 2007; Tocher et al. 2002; Turchini & Francis 2009) and  
299 under certain dietary and environmental conditions, such as the absence of dietary DHA, can be  
300 converted to longer and more unsaturated fatty acid homologues (Bell et al. 2001; Ruyter &  
301 Thomassen 1999; Sissener et al. 2016a; Tocher 2003; Turchini et al. 2013). Owing to these properties,  
302 dietary lipid sources with relatively high concentrations of ALA, such as rapeseed/canola oil,  
303 linseed/flaxseed oil and camelina oil have been routinely used to substitute dietary fish oil both  
304 commercially and experimentally (Bell et al. 2003; Collins et al. 2013; Higgs et al. 2006; Hixson et al.  
305 2017; Turchini et al. 2010). Despite the recorded potential of endogenous production of DHA from  
306 dietary ALA in salmonids, it is not expected to fully compensate for an absence of dietary added DHA  
307 sources, such as fish oil. In the present study, 11 out of the 15 studies in the analysis (Bell et al. (2001),  
308 Bell et al. (2003), Bell et al. (2004), Bell et al. (2010), Friesen et al. (2015), Liland et al. (2013), Rosenlund  
309 et al. (2001), Rosenlund et al. (2016), Sissener et al. (2016a), Torstensen et al. (2004) and Torstensen  
310 et al. (2005)) substituted dietary fish oil with lipid sources containing high concentration of ALA.

311 Consequently, this may explain the negative correlation between dietary ALA and DHA in the present  
312 study.

313

314 Understandably, n-3 LC PUFA are the subject of high scientific interest in fish nutrition studies owing  
315 to their extensively reported health benefits for consumers (Kris-Etherton et al. 2002; Nestel et al.  
316 2015; Ruxton et al. 2004; Simopoulos 2008). However, fillet concentrations of MUFA, in particular,  
317 22:1n-9 and 22:1n-11 receive considerably less attention. Despite this, the sum of 22:1 isomers often  
318 contributes substantially to the overall fatty acid composition of the fillet tissue in Atlantic salmon  
319 (Bell et al. 2010; Bell et al. 2003; Rosenlund et al. 2001; Torstensen et al. 2005; Torstensen et al. 2001)  
320 and was identified as a significant predictor of fillet n-3 LC PUFA in the present study. The activity of  
321 the  $\Delta$ -9 desaturase enzyme, responsible for catalysing the synthesis of monounsaturated fatty acids,  
322 has been well described in marine invertebrates (Monroig et al. 2013) and is considered important for  
323 cold water adaption in warm water fish such as grass carp (*Ctenopharyngodon idella*) and Nile tilapia  
324 (*Oreochromis niloticus*) (Tiku et al. 1996; Zerai et al. 2010). Despite the potential for  $\Delta$ -9 desaturation  
325 of saturated fatty acids to biosynthesise 22:1 isomers, the vast majority of these fatty acids in Atlantic  
326 salmon is believed to be of marine dietary origin – specifically due to an abundance of these fatty acids  
327 present in capelin and herring oil originating in the Northern Hemisphere (Ackman et al. 1988; Bell et  
328 al. 2003; Halver & Hardy 2002). Therefore, the positive relationship between dietary 22:1 and fillet n-  
329 3 LC PUFA is likely an effect of treatment diets containing fish oil sourced from the Northern  
330 Hemisphere, that are concomitantly high in 22:1 and n-3 LC PUFA. However, also it should be noted  
331 that 22:1 has been reported as a preferential substrate for catabolic processes (fatty acid  $\beta$ -oxidation)  
332 in salmonids and thus a larger dietary availability might directly contribute to increased n-3 LC PUFA  
333 retention by sparing them from catabolism (Henderson & Sargent 1985; Henderson et al. 1982;  
334 Stubhaug et al. 2007).

335

336 The final significant predictor included in the fillet n-3 LC PUFA model was dietary EPA which had an  
337 expectedly positive relationship with fillet n-3 LC PUFA. Although physiologically essential, dietary EPA  
338 is often not as well conserved as DHA in Atlantic salmon (Codabaccus et al. 2011; Stubhaug et al. 2007;  
339 Tocher 2010). Nevertheless, its overall contribution to fillet n-3 LC PUFA and importance in predicting  
340 final fillet levels of n-3 LC PUFA is hereby recognised by the model.

341

## 342 **5. Conclusion**

343

344 In conducting the systematic review and analysis of long-term nutritional growth trials focusing on  
345 seawater reared Atlantic salmon, the present study has provided a summary of the current body of  
346 research and has identified the major dietary drivers of fillet DHA and n-3 LC PUFA. Both models  
347 revealed several biologically intuitive variables as having a significant effect on the dependent  
348 variables, namely, fillet DHA and n-3 LC PUFA. It is clear, however, and in agreement with Sales and  
349 Glencross (2011), that the conclusiveness of these findings is limited by a relatively small dataset and  
350 incomplete or inconsistent data reporting in some studies. It is envisaged that continued cooperation  
351 between industry and academia will serve to increase the transparency of available nutritional data.  
352 Furthermore, this cooperation may enable the development of more sophisticated mechanistic  
353 modelling techniques that rely on a suite of environmental and nutritional information to  
354 quantitatively predict fillet n-3 LC PUFA in Atlantic salmon. Nevertheless, the present study provides  
355 a snapshot of the current state of published information that identifies the major drivers of fillet n-3  
356 LC PUFA in post-smolt Atlantic salmon – an important task, given the increasing value of these fatty  
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360 **6. References**

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628

629 Figure 1 caption:  
630 Schematic of systematic review procedure showing number of articles at each stage; i) identification  
631 of articles matching search terms and identified via ad-hoc searching techniques, ii) screening to  
632 remove duplicate articles and articles not on the study species, iii) articles subject to full text  
633 assessment against the pre-determined eligibility criteria and, iv) articles included in the data analysis.

634  
635 Figure 2 caption:  
636 Correlation matrix across all (de-identified) variables.

637  
638 Figure 3 caption:  
639 (Color online) Principal components analyses on stepwise regression outputs for fillet DHA (left)  
640 and fillet PUFA (right) across all non-methodological independent variables. Upper plots are biplots  
641 showing the relative contributions of each variable to each principal component; lower plots show the  
642 proportion of total variance explained by each principal component.

643  
644 Figure 4 caption:  
645 (Color online) Multiple regression of fillet DHA on the three strongest predictors from Fig. 3  
646 (left). Upper left is a perspective view of the 3D regression; dot colours show the actual data values  
647 of fillet DHA whilst rings show the regression model's predictions. The other three subfigures show  
648 perspectives along each axis. The regression model and various statistics are shown.

649  
650 Figure 5 caption:  
651 (Color online) Multiple regression of fillet PUFA on the three strongest predictors from Fig. 3  
652 (left). Upper left is a perspective view of the 3D regression; dot colours show the actual data values  
653 of fillet PUFA whilst rings show the regression model's predictions. The other three subfigures show  
654 perspectives along each axis. The regression model and various statistics are shown.  
655

**Table 1**

Experimental temperature, feed intake and biometry of Atlantic salmon fed 85 different diets from 15 studies.

Study/year	Temperature range (°C)	Temperature average	Initial weight (g)	Final Weight (g)	Weight gain (g)	Feed intake (g)	FCR	Final length (cm)	Fillet yield (%)	Condition factor (K)
(Bell et al. 2001)	7.9-14.2	11.7	83	342	259	339	1.3	30.2	-	1.2
(Bell et al. 2001)	7.9-14.2	11.7	83	342	259	339	1.3	30.2	-	1.2
(Bell et al. 2001)	7.9-14.2	11.7	83	342	259	339	1.3	30.2	-	1.2
(Bell et al. 2001)	7.9-14.2	11.7	83	342	259	339	1.3	30.2	-	1.2
(Bell et al. 2001)	7.9-14.2	11.7	83	342	259	339	1.3	30.2	-	1.2
(Bell et al. 2002)	5.9-14.7	11.0	55	410	354	549	1.6	33.3	-	1.1
(Bell et al. 2002)	5.9-14.7	11.0	53	417	364	535	1.5	33.7	-	1.1
(Bell et al. 2002)	5.9-14.7	11.0	57	394	337	509	1.5	33.1	-	1.1
(Bell et al. 2002)	5.9-14.7	11.0	56	419	363	544	1.5	33.2	-	1.1
(Bell et al. 2003)	5.5-19.6	10.8	120	2100	1980	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2300	2180	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2300	2180	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2100	1980	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2000	1880	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2400	2280	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2600	2480	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2400	2280	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	2300	2180	-	-	-	-	-
(Bell et al. 2003)	5.5-19.6	10.8	120	1900	1780	-	-	-	-	-
(Bell et al. 2004)	5.0-16.8	10.8	127	1790	1663	2245	1.4	-	-	-
(Bell et al. 2004)	5.0-16.8	10.8	127	1890	1763	2274	1.3	-	-	-
(Bell et al. 2004)	5.0-16.8	10.8	127	1900	1773	2500	1.4	-	-	-
(Bell et al. 2004)	5.0-16.8	10.8	127	1870	1743	2248	1.3	-	-	-
(Bell et al. 2004)	5.0-16.8	10.8	127	1870	1743	2353	1.4	-	-	-
(Bell et al. 2010)	5.5-17.0	11.5	81	3120	3039	3738	1.2	65.3	-	1.1
(Bell et al. 2010)	5.5-17.0	11.5	90	3030	2941	4087	1.4	63.7	-	1.2
(Bell et al. 2010)	5.5-17.0	11.5	92	3180	3088	3335	1.1	63.9	-	1.2
(Bell et al. 2010)	5.5-17.0	11.5	84	2840	2756	3279	1.2	62.5	-	1.2
(Bell et al. 2010)	5.5-17.0	11.5	53	2750	2697	2913	1.1	63.1	-	1.1
(Bell et al. 2010)	5.5-17.0	11.5	52	2890	2838	3009	1.1	62.8	-	1.2
(Friesen et al. 2015)	7.9-13.2	-	83	558	475	380	0.8	36.1	-	1.2
(Friesen et al. 2015)	7.9-13.2	-	84	578	494	395	0.8	36.2	-	1.2



(Friesen et al. 2015)	7.9-13.2	-	86	595	510	414	0.8	36.6	-	1.2
(Friesen et al. 2015)	7.9-13.2	-	84	611	527	415	0.8	36.9	-	1.2
(Friesen et al. 2015)	7.9-13.2	-	98	637	539	418	0.8	37.1	-	1.3
(Friesen et al. 2015)	7.9-13.2	-	84	534	450	381	0.8	35.0	-	1.3
(Friesen et al. 2015)	7.9-13.2	-	84	545	460	393	0.9	35.5	-	1.2
(Larsson et al. 2014)	3.0-16.0	8.7	105	3100	2995	2980	1.0	59.6	72.7	1.5
(Larsson et al. 2014)	3.0-16.0	8.7	105	3100	2995	2980	1.0	60.0	72.4	1.5
(Liland et al. 2013)	9.9	9.9	840	3398	2558	2982	1.2	60.2	-	1.6
(Liland et al. 2013)	9.9	9.9	804	3459	2655	2748	1.0	59.3	-	1.6
(Liland et al. 2013)	9.9	9.9	792	3475	2683	2759	1.0	59.5	-	1.7
(Liland et al. 2013)	9.9	9.9	825	3267	2442	2573	1.1	58.3	-	1.6
(Rosenlund et al. 2001)	5-15	-	120	2700	2580	-	-	-	-	-
(Rosenlund et al. 2001)	5-15	-	120	2700	2580	-	-	-	-	-
(Rosenlund et al. 2001)	5-15	-	120	2700	2580	-	-	-	-	-
(Rosenlund et al. 2001)	5-15	-	120	2700	2580	-	-	-	-	-
(Rosenlund et al. 2001)	5-15	-	120	2700	2580	-	-	-	-	-
(Rosenlund et al. 2001)	5-15	-	120	2700	2580	-	-	-	-	-
(Rosenlund et al. 2016)	12.0	12.0	161	2780	2619	2671	1.0	-	-	1.6
(Rosenlund et al. 2016)	12.0	12.0	163	3085	2922	2864	1.0	-	-	1.5
(Rosenlund et al. 2016)	12.0	12.0	161	3056	2895	3011	1.0	-	-	1.6
(Rosenlund et al. 2016)	12.0	12.0	163	3057	2894	2952	1.0	-	-	1.6
(Rosenlund et al. 2016)	12.0	12.0	163	3074	2911	2707	0.9	-	-	1.6
(Rosenlund et al. 2016)	12-6	9.1	161	3249	3088	3242	1.1	-	-	1.8
(Rosenlund et al. 2016)	12-6	9.1	163	3764	3601	3457	1.0	-	-	1.7
(Rosenlund et al. 2016)	12-6	9.1	161	3833	3672	3599	1.0	-	-	1.8
(Rosenlund et al. 2016)	12-6	9.1	163	3639	3476	3406	1.0	-	-	1.7
(Rosenlund et al. 2016)	12-6	9.1	163	3556	3393	3088	0.9	-	-	1.7
(Sissener et al. 2016a)	12.0	12.0	190	764	574	443	0.8	36.8	-	1.5
(Sissener et al. 2016a)	12.0	12.0	192	780	588	444	0.8	36.7	-	1.6
(Sissener et al. 2016a)	12.0	12.0	189	760	571	448	0.8	36.8	-	1.5
(Sissener et al. 2016a)	12.0	12.0	189	765	576	443	0.8	36.3	-	1.5
(Sissener et al. 2016a)	12.0	12.0	190	767	577	436	0.8	36.9	-	1.5
(Sissener et al. 2016a)	12.0	12.0	189	777	588	464	0.8	37.1	-	1.6
(Torstensen et al. 2001)		8.2	148	697	549	494	0.9	-	-	-

(Torstensen et al. 2004)	3.9-15.3	-	143	1463	1320	1406	1.1	-	-	-
(Torstensen et al. 2004)	3.9-15.3	-	143	1463	1320	1406	1.1	-	-	-
(Torstensen et al. 2004)	3.9-15.3	-	143	1463	1320	1406	1.1	-	-	-
(Torstensen et al. 2004)	3.9-15.3	-	143	1463	1320	1406	1.1	-	-	-
(Torstensen et al. 2004)	3.9-15.3	-	143	1463	1320	1406	1.1	-	-	-
(Torstensen et al. 2004)	3.9-15.3	-	143	1463	1320	1406	1.1	-	-	-
(Torstensen et al. 2005)	-	-	50	2515	2465	2514	1.0	-	-	-
(Torstensen et al. 2005)	-	-	120	2380	2260	3028	1.3	-	-	-
(Torstensen et al. 2005)	-	-	50	2420	2370	2323	1.0	-	-	-
(Torstensen et al. 2005)	-	-	120	2698	2578	3145	1.2	-	-	-
(Young et al. 2006)	-	-	52	2075	2023	-	-	-	-	-
(Young et al. 2006)	-	-	52	1975	1923	-	-	-	-	-
(Young et al. 2006)	-	-	52	2562	2510	-	-	-	-	-
(Young et al. 2006)	-	-	52	2168	2116	-	-	-	-	-
(Young et al. 2006)	-	-	52	1936	1884	-	-	-	-	-
(Young et al. 2006)	-	-	52	2458	2406	-	-	-	-	-
(Young et al. 2006)	-	-	52	2113	2061	-	-	-	-	-
(Young et al. 2006)	-	-	52	2193	2141	-	-	-	-	-
(Young et al. 2006)	-	-	52	2512	2460	-	-	-	-	-

Fish oil (%), proximate composition (mg g<sup>-1</sup> diet), and protein: energy ratio of 85 diets from 15 studies fed to Atlantic salmon during experimental trials

**Table 2**

Study/year	Fish oil (% of total added lipid)	Protein	Moisture	Lipid	Ash	Dry matter	NFE	Diet energy (kJ g <sup>-1</sup> diet)	Protein / energy ratio
(Bell et al. 2001)	100	467.0	78.0	277.0	98.0	922.0	80.0	23.3	2.0
(Bell et al. 2001)	90	463.0	81.0	264.0	96.0	919.0	96.0	23.0	2.0
(Bell et al. 2001)	75	448.0	82.0	263.0	96.0	918.0	111.0	22.9	2.0
(Bell et al. 2001)	50	456.0	75.0	257.0	97.0	925.0	115.0	22.9	2.0
(Bell et al. 2001)	0	469.0	68.0	256.0	97.0	932.0	110.0	23.1	2.0
(Bell et al. 2002)	100	464.0	55.0	288.0	84.0	945.0	109.0	24.2	1.9
(Bell et al. 2002)	75	455.0	63.0	279.0	81.0	937.0	122.0	23.9	1.9
(Bell et al. 2002)	50	465.0	49.0	287.0	82.0	951.0	117.0	24.3	1.9
(Bell et al. 2002)	0	466.0	45.0	282.0	83.0	955.0	124.0	24.3	1.9
(Bell et al. 2003)	100	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	66	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	33	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	0	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	66	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	33	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	0	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	0	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	0	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	0	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2003)	33	444.0	72.0	273.0	79.9	928.0	131.1	23.5	1.9
(Bell et al. 2004)	100	441.0	59.0	294.0	71.0	941.0	135.0	24.3	1.8
(Bell et al. 2004)	75	441.0	59.0	294.0	71.0	941.0	135.0	24.3	1.8
(Bell et al. 2004)	50	441.0	59.0	294.0	71.0	941.0	135.0	24.3	1.8
(Bell et al. 2004)	25	441.0	59.0	294.0	71.0	941.0	135.0	24.3	1.8
(Bell et al. 2004)	0	441.0	59.0	294.0	71.0	941.0	135.0	24.3	1.8
(Bell et al. 2010)	100	410.0	46.0	349.0	60.0	954.0	135.0	25.8	1.6
(Bell et al. 2010)	0	405.0	51.0	335.0	60.0	949.0	149.0	25.4	1.6
(Bell et al. 2010)	100	410.0	46.0	349.0	60.0	954.0	135.0	25.8	1.6
(Bell et al. 2010)	0	405.0	51.0	335.0	60.0	949.0	149.0	25.4	1.6
(Bell et al. 2010)	100	410.0	46.0	349.0	60.0	954.0	135.0	25.8	1.6
(Bell et al. 2010)	0	405.0	51.0	335.0	60.0	949.0	149.0	25.4	1.6
(Friesen et al. 2015)	100	453.0	43.0	265.0	90.0	957.0	149.0	23.7	1.9
(Friesen et al. 2015)	50	465.0	45.0	264.0	85.0	955.0	141.0	24.2	1.9
(Friesen et al. 2015)	25	452.0	45.0	260.0	87.0	955.0	156.0	23.9	1.9
(Friesen et al. 2015)	25	453.0	50.0	260.0	88.0	950.0	149.0	24.0	1.9
(Friesen et al. 2015)	25	454.0	42.0	264.0	88.0	958.0	152.0	24.1	1.9
(Friesen et al. 2015)	25	450.0	43.0	255.0	91.0	957.0	161.0	23.4	1.9
(Friesen et al. 2015)	25	449.0	50.0	261.0	86.0	950.0	154.0	24.1	1.9
(Larsson et al. 2014)	73	353.0	73.0	351.0	54.0	927.0	169.0	25.1	1.4
(Larsson et al. 2014)	73	353.0	73.0	351.0	54.0	927.0	169.0	25.1	1.4
(Liland et al. 2013)	100	411.0	70.0	341.0	53.0	930.0	125.0	25.3	1.6
(Liland et al. 2013)	20	408.0	60.0	336.0	52.0	940.0	144.0	25.4	1.6
(Liland et al. 2013)	20	413.0	70.0	345.0	52.0	930.0	120.0	25.4	1.6
(Liland et al. 2013)	20	406.0	70.0	332.0	52.0	930.0	140.0	25.1	1.6
(Rosenlund et al. 2001)	40-50	426.0	34.8	338.0	54.3	965.3	147.0	25.9	1.6
(Rosenlund et al. 2001)	40-50	426.0	34.8	338.0	54.3	965.3	147.0	25.9	1.6
(Rosenlund et al. 2001)	40-50	426.0	34.8	338.0	54.3	965.3	147.0	25.9	1.6
(Rosenlund et al. 2001)	40-50	426.0	34.8	338.0	54.3	965.3	147.0	25.9	1.6
(Rosenlund et al. 2001)	40-50	426.0	34.8	338.0	54.3	965.3	147.0	25.9	1.6

(Rosenlund et al. 2001)	40-50	426.0	34.8	338.0	54.3	965.3	147.0	25.9	1.6
(Rosenlund et al. 2016)	0	436.4	58.8	365.1	79.9	941.2	59.9	25.7	1.7
(Rosenlund et al. 2016)	2	431.1	58.0	363.8	79.9	942.0	67.3	25.7	1.7
(Rosenlund et al. 2016)	4	431.6	60.2	363.8	79.9	939.8	64.6	25.7	1.7
(Rosenlund et al. 2016)	6	429.7	62.3	361.5	79.9	937.7	66.6	25.6	1.7
(Rosenlund et al. 2016)	8	431.0	65.5	366.2	79.9	934.5	57.5	25.6	1.7
(Rosenlund et al. 2016)	0	436.4	58.8	365.1	79.9	941.2	59.9	25.7	1.7
(Rosenlund et al. 2016)	2	431.1	58.0	363.8	79.9	942.0	67.3	25.7	1.7
(Rosenlund et al. 2016)	4	431.6	60.2	363.8	79.9	939.8	64.6	25.7	1.7
(Rosenlund et al. 2016)	6	429.7	62.3	361.5	79.9	937.7	66.6	25.6	1.7
(Rosenlund et al. 2016)	8	431.0	65.5	366.2	79.9	934.5	57.5	25.6	1.7
(Sissener et al. 2016a)	20	489.1	39.0	275.8	79.9	961.0	116.3	24.4	2.0
(Sissener et al. 2016a)	20	500.5	41.0	280.5	79.9	959.0	98.1	24.6	2.0
(Sissener et al. 2016a)	20	502.1	44.0	288.7	79.9	956.0	85.3	24.7	2.0
(Sissener et al. 2016a)	20	502.6	45.0	277.5	79.9	955.0	95.0	24.5	2.1
(Sissener et al. 2016a)	20	520.3	39.0	278.9	79.9	961.0	81.9	24.7	2.1
(Sissener et al. 2016a)	20	522.5	43.0	294.7	79.9	957.0	60.0	25.0	2.1
(Torstensen et al. 2001)	100	450.0	50.0	323.8	65.0	950.0	111.2	25.3	1.8
(Torstensen et al. 2004)	75	450.0	60.0	300.0	70.0	940.0	120.0	24.5	1.8
(Torstensen et al. 2004)	50	450.0	60.0	300.0	70.0	940.0	120.0	24.5	1.8
(Torstensen et al. 2004)	25	450.0	60.0	300.0	70.0	940.0	120.0	24.5	1.8
(Torstensen et al. 2004)	0	450.0	60.0	300.0	70.0	940.0	120.0	24.5	1.8
(Torstensen et al. 2004)	50	450.0	60.0	300.0	70.0	940.0	120.0	24.5	1.8
(Torstensen et al. 2004)	100	450.0	60.0	300.0	70.0	940.0	120.0	24.5	1.8
(Torstensen et al. 2005)	100	421.0	70.0	314.0	70.0	930.0	125.0	24.5	1.7
(Torstensen et al. 2005)	100	421.0	70.0	314.0	70.0	930.0	125.0	24.5	1.7
(Torstensen et al. 2005)	25	412.0	64.0	328.0	71.0	936.0	125.0	24.8	1.7
(Torstensen et al. 2005)	0	429.0	65.0	313.0	66.0	935.0	127.0	24.7	1.7
(Young et al. 2006)	13.7	427.1	80.5	211.3	89.7	919.5	191.5	21.7	2.0
(Young et al. 2006)	13.8	423.3	81.6	208.5	84.5	918.4	202.1	21.7	2.0
(Young et al. 2006)	14.3	418.2	80.3	205.7	86.3	919.7	209.6	21.6	1.9
(Young et al. 2006)	19.9	406.8	70.8	278.2	84.5	929.3	159.8	23.3	1.7
(Young et al. 2006)	19.9	411.5	71.3	267.4	86.3	928.7	163.5	23.1	1.8
(Young et al. 2006)	20.4	412.5	71.2	269.7	83.4	928.8	163.3	23.2	1.8
(Young et al. 2006)	26.2	413.5	54.4	336.1	86.1	945.6	109.9	24.9	1.7
(Young et al. 2006)	26.4	420.7	55.4	322.7	92.4	944.6	108.8	24.5	1.7
(Young et al. 2006)	26.7	414.6	57.4	325.2	88.0	942.6	114.8	24.6	1.7

**Table 3**Fatty acid composition of 85 diets from 15 studies fed to Atlantic salmon during experimental trials (mg g<sup>-1</sup> diet)

Study/year	14:0	16:0	18:0	SFA	20:1	22:1	18:1n-9	18:2n-6	20:4n-6	18:3n-3	18:4n-3	20:4n-3	20:5n-3	22:5n-3	22:6n-3	n-3 LC PUFA
(Bell et al. 2001)	-	-	-	50.8	17.2	25.3	26.1	5.1	1.3	3.4	-	-	18.1	-	25.3	43.3
(Bell et al. 2001)	-	-	-	43.3	15.0	20.9	38.1	10.3	0.8	5.9	-	-	13.8	-	20.4	34.2
(Bell et al. 2001)	-	-	-	39.1	12.7	16.5	47.0	14.3	0.8	7.7	-	-	13.1	-	17.5	30.7
(Bell et al. 2001)	-	-	-	34.3	10.8	13.6	58.3	18.5	0.6	9.7	-	-	10.2	-	13.4	23.6
(Bell et al. 2001)	-	-	-	23.4	5.9	4.5	86.2	30.2	0.4	15.9	-	-	5.1	-	5.5	10.6
(Bell et al. 2002)	11.5	38.9	5.3	59.8	9.3	14.1	38.0	7.9	1.3	4.6	7.1	1.5	18.1	2.2	30.0	50.3
(Bell et al. 2002)	9.4	47.7	6.0	66.1	7.7	11.1	45.4	11.3	1.1	3.6	5.6	1.3	14.1	1.9	23.5	39.6
(Bell et al. 2002)	7.7	58.5	6.8	75.5	6.6	9.5	55.7	15.0	0.9	2.9	4.4	0.9	11.4	1.5	19.1	32.1
(Bell et al. 2002)	3.7	88.2	8.4	101.8	3.2	4.3	67.5	20.3	0.2	1.1	1.3	0.2	3.5	0.6	6.1	10.2
(Bell et al. 2003)	11.7	28.5	5.2	50.2	20.1	27.6	31.6	9.4	1.3	3.6	5.9	1.7	15.3	2.5	22.0	41.4
(Bell et al. 2003)	7.5	24.3	6.1	42.3	12.6	17.2	33.7	16.5	0.8	38.9	3.8	1.3	11.1	2.1	17.6	32.0
(Bell et al. 2003)	4.6	20.1	7.1	35.0	7.7	10.0	34.3	23.9	0.6	69.1	2.1	0.6	6.9	1.3	11.1	19.9
(Bell et al. 2003)	2.3	15.9	7.5	27.6	4.0	4.8	34.7	28.5	0.4	95.0	1.0	0.2	3.8	0.6	5.7	10.3
(Bell et al. 2003)	7.7	24.5	4.8	41.7	13.6	17.4	55.9	19.9	1.0	9.8	4.0	1.3	11.9	2.3	18.2	33.7
(Bell et al. 2003)	4.8	19.7	4.2	32.4	9.6	11.3	78.5	29.3	0.6	13.8	2.3	0.8	8.2	1.3	12.4	22.6
(Bell et al. 2003)	2.5	15.1	4.0	23.9	6.3	5.7	101.1	37.5	0.4	18.6	0.8	0.2	4.0	0.6	6.1	10.9
(Bell et al. 2003)	2.5	16.1	6.3	27.2	4.6	5.4	54.2	30.6	0.4	68.9	0.8	0.4	4.6	0.8	7.1	13.0
(Bell et al. 2003)	2.3	15.9	5.0	22.8	5.4	5.7	77.2	34.2	0.4	42.3	0.8	0.2	4.4	0.8	7.3	12.8
(Bell et al. 2003)	4.0	18.4	5.7	31.2	7.3	9.0	60.3	28.7	0.4	46.1	1.9	0.4	6.5	1.0	10.3	18.2
(Bell et al. 2004)	14.2	27.3	2.5	44.9	40.4	34.7	26.8	9.5	0.5	2.0	6.5	0.9	13.3	-	11.3	24.6
(Bell et al. 2004)	10.6	23.9	3.8	38.8	29.5	26.2	30.7	16.7	0.5	31.6	4.7	0.7	10.4	-	9.0	19.4
(Bell et al. 2004)	7.7	21.0	4.7	34.0	20.3	18.3	34.0	22.1	0.2	57.7	3.6	0.5	7.9	-	7.7	15.6
(Bell et al. 2004)	4.5	18.3	6.1	29.3	11.3	10.8	36.1	27.7	0.2	85.2	2.0	0.5	5.0	-	5.4	10.4
(Bell et al. 2004)	0.9	13.8	7.0	23.7	2.5	2.7	38.3	34.0	0.2	113.6	0.5	0.2	2.3	-	3.4	5.6
(Bell et al. 2010)	15.5	40.1	8.0	69.8	22.7	36.7	27.0	9.4	1.1	4.3	9.4	1.6	22.7	2.1	27.0	51.9
(Bell et al. 2010)	2.3	40.8	9.0	55.7	10.3	4.1	96.6	42.4	0.3	25.7	1.0	0.3	3.1	0.3	3.9	7.2
(Bell et al. 2010)	15.5	40.1	8.0	69.8	22.7	36.7	27.0	9.4	1.1	4.3	9.4	1.6	22.7	2.1	27.0	51.9
(Bell et al. 2010)	2.3	40.8	9.0	55.7	10.3	4.1	96.6	42.4	0.3	25.7	1.0	0.3	3.1	0.3	3.9	7.2
(Bell et al. 2010)	15.5	40.1	8.0	69.8	22.7	36.7	27.0	9.4	1.1	4.3	9.4	1.6	22.7	2.1	27.0	51.9
(Bell et al. 2010)	2.3	40.8	9.0	55.7	10.3	4.1	96.6	42.4	0.3	25.7	1.0	0.3	3.1	0.3	3.9	7.2
(Friesen et al. 2015)	15.2	36.2	7.1	60.1	-	2.6	25.2	12.6	3.3	2.0	4.9	1.6	38.2	4.3	16.7	59.1

(Friesen et al. 2015)	8.1	39.9	9.9	58.9	-	1.6	56.1	22.1	2.0	3.4	2.4	0.8	18.4	2.2	8.5	29.1
(Friesen et al. 2015)	6.2	40.5	9.8	57.4	-	1.0	60.6	24.9	1.2	5.8	1.8	0.6	13.2	1.8	7.4	22.3
(Friesen et al. 2015)	5.0	18.7	7.4	31.7	-	0.8	30.5	27.1	1.0	73.0	1.6	0.4	12.4	1.6	6.6	20.5
(Friesen et al. 2015)	5.3	19.2	4.9	29.8	-	0.8	77.3	34.6	1.0	16.2	1.6	0.4	12.6	1.6	6.7	20.9
(Friesen et al. 2015)	5.1	18.0	4.7	28.4	-	1.0	74.3	33.4	1.2	14.9	1.8	0.6	13.1	1.6	5.9	20.5
(Friesen et al. 2015)	5.4	18.6	4.8	29.2	-	1.0	76.0	34.2	1.0	15.4	1.8	0.4	13.2	1.6	6.0	20.8
(Larsson et al. 2014)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Larsson et al. 2014)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Liland et al. 2013)	17.8	41.6	7.6	70.1	14.6	26.7	31.1	7.1	1.3	3.7	6.8	1.8	21.2	-	26.1	-
(Liland et al. 2013)	3.9	31.9	8.5	46.4	3.6	5.2	129.6	31.2	0.3	10.6	1.3	0.5	4.9	-	5.9	-
(Liland et al. 2013)	5.3	20.6	6.6	34.9	6.3	7.4	113.0	41.8	0.5	20.6	1.9	0.5	6.6	-	7.9	-
(Liland et al. 2013)	4.3	37.7	9.7	54.0	3.6	5.6	54.7	95.5	0.3	11.2	1.5	0.5	5.1	-	6.1	-
(Rosenlund et al. 2001)	-	30.1	-	-	19.3	22.0	95.0	41.9		34.5	-	-	11.8	-	10.8	22.6
(Rosenlund et al. 2001)	-	51.4	-	-	3.7	2.7	56.8	34.1		76.4	-	-	20.3	-	16.6	36.8
(Rosenlund et al. 2001)	-	45.3	-	-	14.5	15.5	92.6	35.2		10.8	-	-	13.5	-	11.8	25.4
(Rosenlund et al. 2001)	-	54.8	-	-	16.6	21.0	62.9	32.1		57.5	-	-	11.8	-	10.8	22.6
(Rosenlund et al. 2001)	-	42.9	-	-	41.9	51.0	35.5	12.8		3.7	-	-	25.4	-	19.3	44.6
(Rosenlund et al. 2001)	-	49.7	-	-	4.4	3.7	52.1	88.2		10.8	-	-	25.4	-	19.9	45.3
(Rosenlund et al. 2016)	1.8	41.8	6.8	52.2	3.7	2.2	-	46.3	0.0	35.0	0.4	0.0	2.2	0.3	2.1	4.6
(Rosenlund et al. 2016)	3.3	41.6	6.5	53.6	4.6	3.7	-	43.9	0.3	32.0	1.0	0.3	4.0	0.6	3.7	8.3
(Rosenlund et al. 2016)	4.3	41.9	6.3	54.4	5.4	4.7	-	41.6	0.3	30.7	1.2	0.3	5.1	0.6	4.6	10.4
(Rosenlund et al. 2016)	5.1	41.7	6.4	55.4	6.1	5.7	-	40.0	0.3	28.4	1.7	0.3	6.4	0.8	5.7	12.9
(Rosenlund et al. 2016)	6.4	42.1	6.4	56.9	7.0	6.9	-	38.7	0.5	27.4	2.0	0.5	7.9	1.1	7.0	16.0
(Rosenlund et al. 2016)	1.8	41.8	6.8	52.2	3.7	2.2	-	46.3	0.0	35.0	0.4	0.0	2.2	0.3	2.1	4.6
(Rosenlund et al. 2016)	3.3	41.6	6.5	53.6	4.6	3.7	-	43.9	0.3	32.0	1.0	0.3	4.0	0.6	3.7	8.3
(Rosenlund et al. 2016)	4.3	41.9	6.3	54.4	5.4	4.7	-	41.6	0.3	30.7	1.2	0.3	5.1	0.6	4.6	10.4
(Rosenlund et al. 2016)	5.1	41.7	6.4	55.4	6.1	5.7	-	40.0	0.3	28.4	1.7	0.3	6.4	0.8	5.7	12.9
(Rosenlund et al. 2016)	6.4	42.1	6.4	56.9	7.0	6.9	-	38.7	0.5	27.4	2.0	0.5	7.9	1.1	7.0	16.0
(Sissener et al. 2016a)	4.5	15.0	4.1	25.8	7.7	9.1	80.9	29.7	0.2	18.5	1.8	-	4.9	-	5.7	10.6
(Sissener et al. 2016a)	4.7	35.7	6.0	48.3	6.8	8.5	71.2	24.3	0.2	20.4	1.7	-	4.5	-	5.2	9.7
(Sissener et al. 2016a)	3.8	41.9	7.8	55.4	3.6	5.3	52.3	52.1	0.2	22.0	1.3	-	4.0	-	5.3	9.3
(Sissener et al. 2016a)	2.8	23.4	6.5	34.9	3.5	4.7	40.4	77.6	0.2	21.7	1.0	-	3.7	-	4.7	8.5
(Sissener et al. 2016a)	4.1	19.1	5.3	30.2	6.8	8.2	57.5	52.0	0.2	19.9	1.6	-	4.5	-	4.9	9.5
(Sissener et al. 2016a)	3.9	34.4	6.5	46.9	4.5	5.4	64.4	48.2	0.2	21.8	1.3	-	4.3	-	5.6	9.9



**Table 4**

Proximate composition of fillet tissue of Atlantic salmon fed 85 different diets from 15 studies (mg g<sup>-1</sup> of fillet tissue)

Study/year	Protein	Moisture	Lipid	Ash
(Bell et al. 2001)	185	747	54	15
(Bell et al. 2001)	189	751	48	17
(Bell et al. 2001)	191	752	46	14
(Bell et al. 2001)	191	752	45	17
(Bell et al. 2001)	195	742	51	14
(Bell et al. 2002)	203	728	57	15
(Bell et al. 2002)	199	739	47	16
(Bell et al. 2002)	202	742	41	15
(Bell et al. 2002)	205	741	38	17
(Bell et al. 2003)	-	-	86	-
(Bell et al. 2003)	-	-	76	-
(Bell et al. 2003)	-	-	95	-
(Bell et al. 2003)	-	-	75	-
(Bell et al. 2003)	-	-	81	-
(Bell et al. 2003)	-	-	78	-
(Bell et al. 2003)	-	-	70	-
(Bell et al. 2003)	-	-	70	-
(Bell et al. 2003)	-	-	75	-
(Bell et al. 2003)	-	-	69	-
(Bell et al. 2004)	-	-	81	-
(Bell et al. 2004)	-	-	81	-
(Bell et al. 2004)	-	-	81	-
(Bell et al. 2004)	-	-	81	-
(Bell et al. 2004)	-	-	81	-
(Bell et al. 2010)	194	-	116	-
(Bell et al. 2010)	199	-	128	-
(Bell et al. 2010)	191	-	132	-
(Bell et al. 2010)	192	-	129	-
(Bell et al. 2010)	193	-	123	-
(Bell et al. 2010)	195	-	113	-
(Friesen et al. 2015)	-	-	65	-
(Friesen et al. 2015)	-	-	70	-
(Friesen et al. 2015)	-	-	68	-
(Friesen et al. 2015)	-	-	60	-
(Friesen et al. 2015)	-	-	66	-
(Friesen et al. 2015)	-	-	64	-
(Friesen et al. 2015)	-	-	73	-
(Larsson et al. 2014)	234	-	143	-
(Larsson et al. 2014)	236	-	143	-
(Liland et al. 2013)	-	-	131	-
(Liland et al. 2013)	-	-	150	-
(Liland et al. 2013)	-	-	142	-
(Liland et al. 2013)	-	-	134	-
(Rosenlund et al. 2001)	203	680	106	14
(Rosenlund et al. 2001)	204	688	97	13
(Rosenlund et al. 2001)	205	682	103	14
(Rosenlund et al. 2001)	200	676	113	14
(Rosenlund et al. 2001)	204	669	117	13



(Rosenlund et al. 2001)	200	662	127	13
(Rosenlund et al. 2016)	-	-	165	-
(Rosenlund et al. 2016)	-	-	152	-
(Rosenlund et al. 2016)	-	-	159	-
(Rosenlund et al. 2016)	-	-	142	-
(Rosenlund et al. 2016)	-	-	150	-
(Rosenlund et al. 2016)	-	-	137	-
(Rosenlund et al. 2016)	-	-	143	-
(Rosenlund et al. 2016)	-	-	130	-
(Rosenlund et al. 2016)	-	-	138	-
(Rosenlund et al. 2016)	-	-	133	-
(Sissener et al. 2016a)	210	669	124	-
(Sissener et al. 2016a)	213	674	117	-
(Sissener et al. 2016a)	210	673	121	-
(Sissener et al. 2016a)	213	672	112	-
(Sissener et al. 2016a)	210	673	118	-
(Sissener et al. 2016a)	210	671	115	-
(Torstensen et al. 2001)	-	-	130	-
(Torstensen et al. 2004)	207	-	66	-
(Torstensen et al. 2004)	207	-	71	-
(Torstensen et al. 2004)	207	-	81	-
(Torstensen et al. 2004)	212	-	70	-
(Torstensen et al. 2004)	204	-	64	-
(Torstensen et al. 2004)	209	-	66	-
(Torstensen et al. 2005)	-	-	126	-
(Torstensen et al. 2005)	-	-	87	-
(Torstensen et al. 2005)	-	-	116	-
(Torstensen et al. 2005)	-	-	98	-
(Young et al. 2006)	-	-	95	-
(Young et al. 2006)	-	-	113	-
(Young et al. 2006)	-	-	151	-
(Young et al. 2006)	-	-	92	-
(Young et al. 2006)	-	-	102	-
(Young et al. 2006)	-	-	131	-
(Young et al. 2006)	-	-	93	-
(Young et al. 2006)	-	-	105	-
(Young et al. 2006)	-	-	145	-

**Table 5**Fatty acid composition of fillet tissue of Atlantic salmon fed 85 different diets from 15 studies (mg 100g<sup>-1</sup> of fillet)

Study/year	14:0	16:0	18:0	SFA	20:1	22:1	18:1n-9	18:2n-6	20:4n-6	18:3n-3	18:4n-3	20:4n-3	20:5n-3	22:5n-3	22:6n-3	n-3 LC PUFA
(Bell et al. 2001)	165.1	732.4	114.3	1037.3	321.8	376.8	724.0	105.8	21.2	59.3	84.7	63.5	245.6	88.9	626.6	961.1
(Bell et al. 2001)	149.8	685.3	101.1	962.5	235.9	250.9	876.3	179.8	15.0	78.6	56.2	41.2	157.3	52.4	434.4	644.1
(Bell et al. 2001)	124.4	567.0	102.4	815.8	208.5	219.5	951.1	226.8	14.6	106.1	47.6	43.9	168.3	62.2	424.4	654.8
(Bell et al. 2001)	92.2	450.6	99.3	663.4	195.1	198.7	1011.1	287.4	14.2	141.9	42.6	39.0	152.6	60.3	397.4	610.2
(Bell et al. 2001)	56.3	414.2	108.6	595.1	164.9	104.5	1572.2	494.6	16.1	225.2	28.1	28.1	112.6	44.2	289.5	446.3
(Bell et al. 2002)	189.4	802.7	130.8	1168.0	216.5	216.5	825.3	153.3	22.5	81.2	90.2	67.6	257.1	85.7	735.1	1077.8
(Bell et al. 2002)	122.8	744.3	122.8	1019.6	160.0	148.9	822.4	182.3	18.6	55.8	59.5	48.4	182.3	63.3	561.9	807.5
(Bell et al. 2002)	86.4	694.6	108.8	912.3	128.0	112.0	806.6	192.1	12.8	38.4	38.4	35.2	134.4	48.0	467.3	649.8
(Bell et al. 2002)	47.6	701.5	110.0	867.9	101.1	53.5	1105.7	315.1	11.9	14.9	11.9	11.9	56.5	17.8	228.9	303.2
(Bell et al. 2003)	297.4	956.8	181.0	1493.4	523.7	646.5	982.7	284.5	32.3	90.5	109.9	103.4	362.0	161.6	827.5	1454.6
(Bell et al. 2003)	219.8	834.0	213.3	1318.9	375.0	465.5	995.6	459.0	25.9	969.7	77.6	97.0	252.1	116.4	614.2	1079.6
(Bell et al. 2003)	148.7	711.1	219.8	1118.4	239.2	271.5	1047.3	601.2	19.4	1706.7	71.1	97.0	174.6	84.0	439.6	795.2
(Bell et al. 2003)	77.6	588.3	245.7	943.9	129.3	122.8	1079.6	756.4	6.5	2417.9	64.6	103.4	103.4	38.8	271.5	517.2
(Bell et al. 2003)	219.8	808.1	174.6	1254.2	407.3	459.0	1609.8	549.5	25.9	245.7	77.6	84.0	258.6	122.8	646.5	1112.0
(Bell et al. 2003)	155.2	698.2	168.1	1066.7	329.7	278.0	2211.0	769.3	19.4	342.6	45.3	58.2	168.1	77.6	459.0	762.9
(Bell et al. 2003)	84.0	575.4	168.1	879.2	252.1	129.3	2683.0	943.9	12.9	439.6	38.8	45.3	97.0	38.8	323.2	504.3
(Bell et al. 2003)	77.6	575.4	206.9	892.2	161.6	122.8	1648.6	846.9	12.9	1706.7	71.1	84.0	109.9	38.8	297.4	530.1
(Bell et al. 2003)	84.0	588.3	187.5	905.1	213.3	142.2	2139.9	879.2	12.9	1066.7	58.2	77.6	116.4	45.3	303.9	543.1
(Bell et al. 2003)	148.7	711.1	193.9	1099.0	290.9	297.4	1622.7	691.8	19.4	1008.5	58.2	77.6	161.6	71.1	452.5	762.9
(Bell et al. 2004)	274.2	752.6	110.9	1161.0	968.5	577.6	933.5	227.5	17.5	46.7	87.5	70.0	250.9	87.5	472.6	811.0
(Bell et al. 2004)	270.6	811.7	159.6	1255.8	825.6	506.5	1207.2	471.8	13.9	797.9	90.2	97.1	208.1	76.3	423.2	707.7
(Bell et al. 2004)	185.2	683.3	178.8	1053.7	555.6	344.9	1124.0	549.2	12.8	1283.6	83.0	95.8	159.7	63.9	338.5	562.0
(Bell et al. 2004)	51.1	613.1	198.0	938.8	306.5	191.6	1124.0	702.5	6.4	1922.2	76.6	102.2	115.0	38.3	274.6	427.9
(Bell et al. 2004)	44.7	530.0	229.9	811.0	102.2	70.2	1187.8	836.6	6.4	2471.4	76.6	115.0	83.0	25.5	198.0	306.5
(Bell et al. 2010)	411.6	1371.8	237.8	2066.9	695.1	777.4	1618.8	448.1	36.6	164.6	155.5	155.5	530.4	265.2	1198.1	1993.7
(Bell et al. 2010)	141.3	1322.0	292.7	1806.4	524.8	201.8	3804.6	1412.8	20.2	676.1	70.6	90.8	171.6	90.8	403.7	666.0
(Bell et al. 2010)	478.7	1561.1	281.0	2372.8	780.5	874.2	1852.4	509.9	41.6	197.7	187.3	176.9	593.2	291.4	1332.1	2216.7
(Bell et al. 2010)	152.6	1393.4	305.1	1912.1	518.7	223.8	3793.6	1352.7	20.3	640.7	81.4	91.5	193.2	91.5	427.2	711.9
(Bell et al. 2010)	436.4	1493.4	271.5	2240.1	707.9	785.5	1794.0	484.9	38.8	174.6	145.5	155.2	533.4	271.5	1231.6	2036.5
(Bell et al. 2010)	133.6	1229.4	285.1	1683.8	454.4	178.2	3305.3	1184.9	17.8	552.4	62.4	71.3	169.3	80.2	400.9	650.4
(Friesen et al. 2015)	317.7	876.3	184.5	1414.4	–	71.7	650.8	287.0	41.0	51.2	87.1	66.6	738.0	235.7	666.2	1639.9
(Friesen et al. 2015)	193.2	998.9	253.9	1479.1	–	38.6	1528.7	579.5	27.6	82.8	44.2	38.6	358.7	121.4	397.4	877.5

(Friesen et al. 2015)	155.5	981.1	252.0	1404.6	-	21.4	1635.2	611.2	32.2	117.9	32.2	32.2	225.2	91.1	375.3	691.6
(Friesen et al. 2015)	108.8	506.2	184.5	818.4	-	18.9	1036.0	624.4	18.9	1088.0	47.3	52.0	198.7	75.7	302.7	577.1
(Friesen et al. 2015)	119.7	562.0	187.3	884.6	-	20.8	1790.0	759.7	20.8	431.9	41.6	46.8	223.8	83.3	322.6	629.6
(Friesen et al. 2015)	126.1	539.9	151.4	832.6	-	20.2	1781.2	761.9	25.2	328.0	45.4	30.3	227.1	80.7	302.7	610.5
(Friesen et al. 2015)	132.4	604.3	178.4	932.4	-	23.0	2077.7	851.8	28.8	385.6	40.3	40.3	264.7	92.1	351.1	707.9
(Larsson et al. 2014)	-	-	-	1989.9	-	-	-	-	-	-	-	-	-	213.1	-	-
(Larsson et al. 2014)	-	-	-	2127.5	-	-	-	-	-	-	-	-	-	192.8	-	-
(Liland et al. 2013)	-	-	-	-	-	-	-	-	-	-	-	-	745.7	-	1252.8	1998.5
(Liland et al. 2013)	-	-	-	-	-	-	-	-	-	-	-	-	234.2	-	600.8	834.9
(Liland et al. 2013)	-	-	-	-	-	-	-	-	-	-	-	-	257.5	-	585.5	843.0
(Liland et al. 2013)	-	-	-	-	-	-	-	-	-	-	-	-	200.7	-	486.0	686.7
(Rosenlund et al. 2001)	-	996.4	-	1537.0	614.8	455.8	3360.2	1208.4	-	710.2	-	-	307.4	-	551.2	858.6
(Rosenlund et al. 2001)	-	1280.4	-	1930.3	184.3	106.7	1784.8	911.8	-	1736.3	-	-	378.3	-	640.2	1018.5
(Rosenlund et al. 2001)	-	1194.8	-	1874.6	597.4	432.6	3069.4	968.2	-	309.0	-	-	298.7	-	597.4	896.1
(Rosenlund et al. 2001)	-	1627.2	-	2282.6	621.5	531.1	2531.2	1017.0	-	1446.4	-	-	316.4	-	553.7	870.1
(Rosenlund et al. 2001)	-	1439.1	-	2258.1	1415.7	1368.9	1544.4	468.0	-	105.3	-	-	631.8	-	900.9	1532.7
(Rosenlund et al. 2001)	-	1612.9	-	2540.0	215.9	114.3	2095.5	3048.0	-	368.3	-	-	647.7	-	990.6	1638.3
(Rosenlund et al. 2016)	91.1	1626.1	416.3	2224.5	299.2	104.1	-	1678.1	26.0	897.6	234.2	104.1	130.1	52.0	273.2	455.3
(Rosenlund et al. 2016)	131.8	1545.9	371.5	2157.1	323.6	143.8	-	1474.0	24.0	814.9	155.8	95.9	143.8	59.9	299.6	503.3
(Rosenlund et al. 2016)	163.0	1642.2	388.6	2306.6	363.5	188.0	-	1541.9	25.1	877.5	163.0	87.8	163.0	62.7	376.1	601.7
(Rosenlund et al. 2016)	179.1	1444.2	335.9	2060.0	347.1	190.3	-	1332.3	22.4	761.3	134.3	89.6	156.7	67.2	380.6	604.6
(Rosenlund et al. 2016)	224.7	1561.1	354.8	2247.0	390.3	248.3	-	1360.0	23.7	816.0	130.1	94.6	201.0	82.8	461.2	745.0
(Rosenlund et al. 2016)	75.6	1306.9	334.8	1793.0	248.4	75.6	-	1425.8	32.4	723.7	216.0	97.2	118.8	54.0	216.0	388.8
(Rosenlund et al. 2016)	124.0	1386.7	349.5	1927.9	304.4	124.0	-	1465.7	22.5	777.9	169.1	101.5	146.6	67.6	259.3	473.5
(Rosenlund et al. 2016)	143.5	1281.2	317.7	1814.1	307.5	143.5	-	1301.7	20.5	717.5	133.2	92.2	143.5	61.5	276.7	481.7
(Rosenlund et al. 2016)	174.1	1349.1	293.8	1893.1	348.2	174.1	-	1360.0	21.8	772.5	119.7	97.9	185.0	76.2	359.0	620.2
(Rosenlund et al. 2016)	199.2	1310.7	304.1	1897.9	346.0	209.7	-	1258.3	21.0	713.0	115.3	94.4	199.2	83.9	408.9	692.1
(Sissener et al. 2016a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Sissener et al. 2016a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Sissener et al. 2016a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Sissener et al. 2016a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Sissener et al. 2016a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Sissener et al. 2016a)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Torstensen et al. 2001)	593.2	1404.9	239.4	2268.7	1207.2	1488.2	1280.1	166.5	52.0	104.1	-	156.1	572.4	208.1	1259.2	2039.8



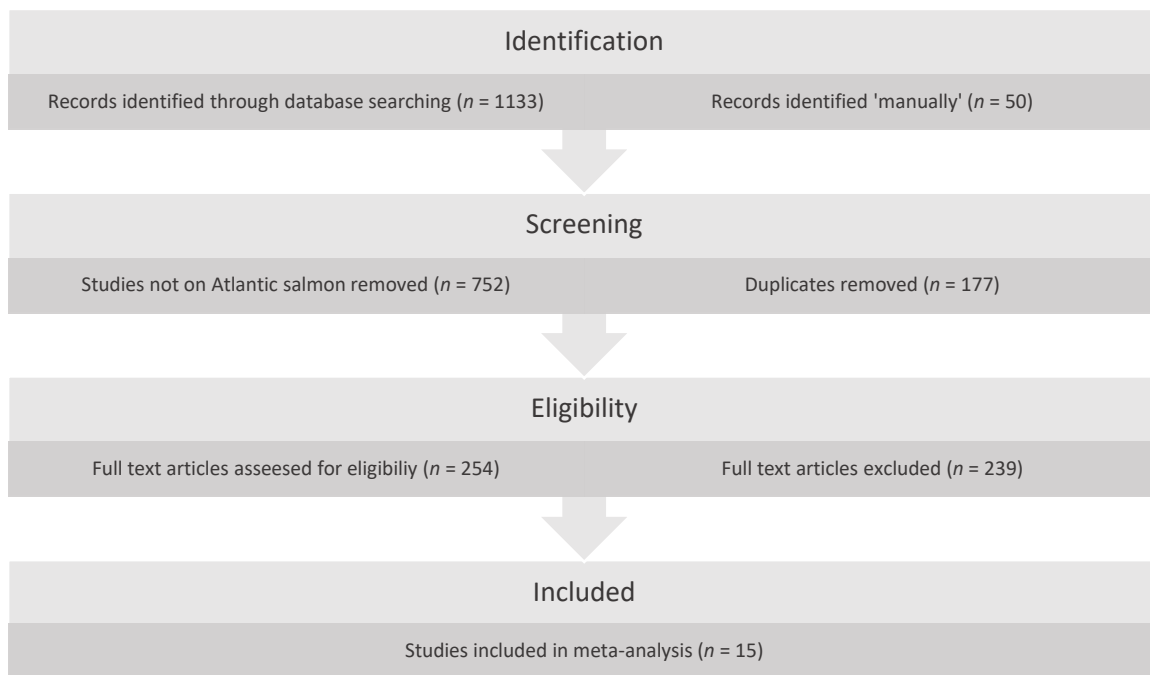


Figure 1

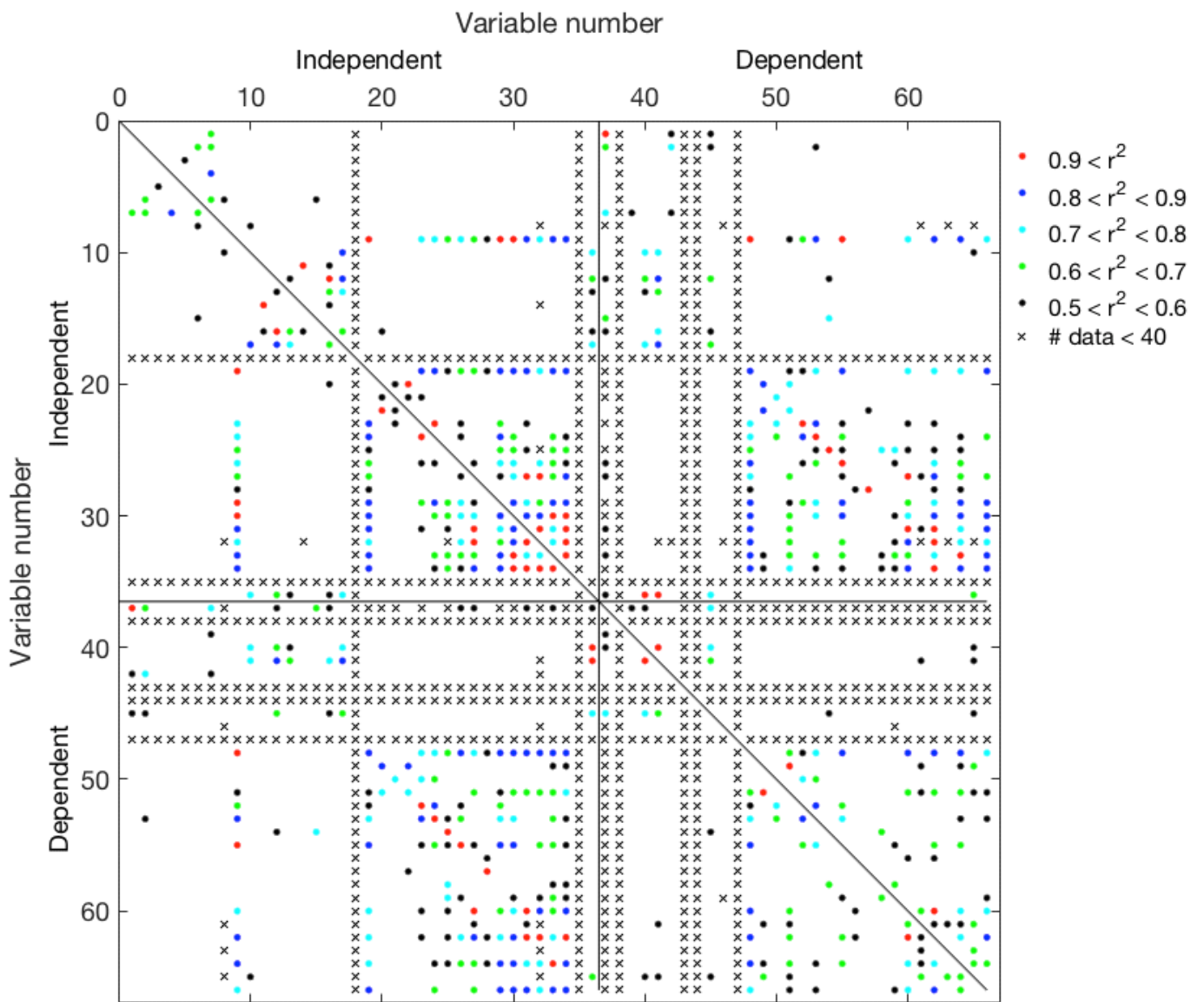
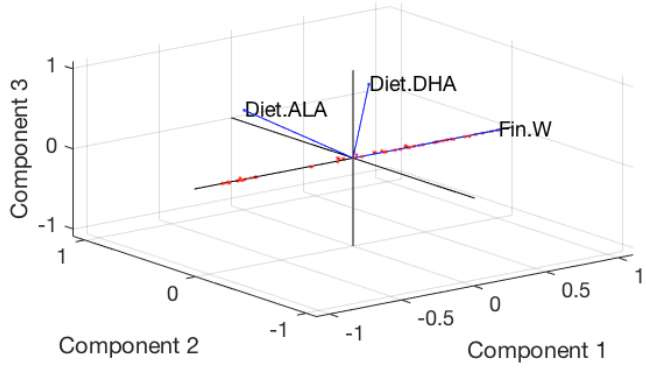


Figure 2

**Fillet.DHA stepwise regression output**



**Fillet.n-3.LC.PUFA stepwise regression output**

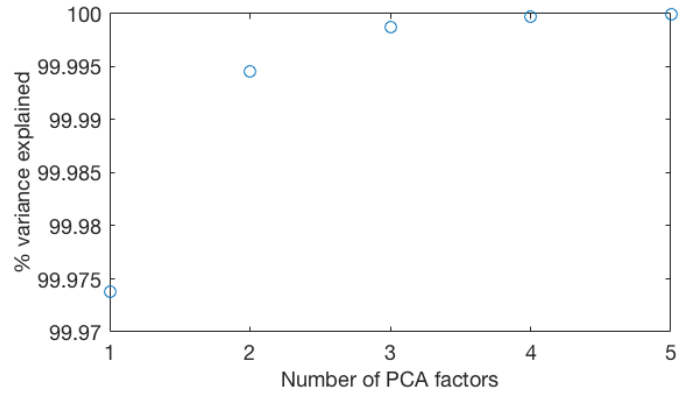
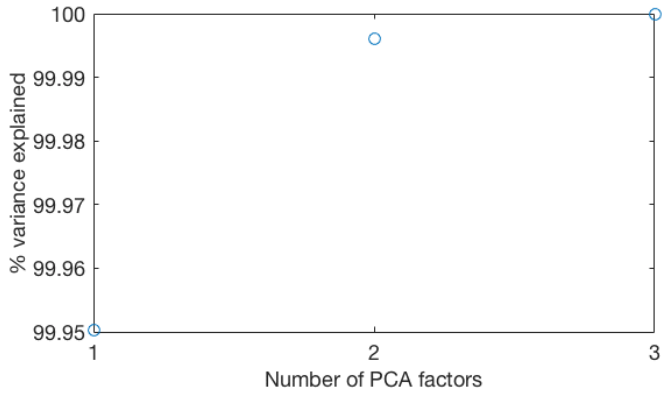
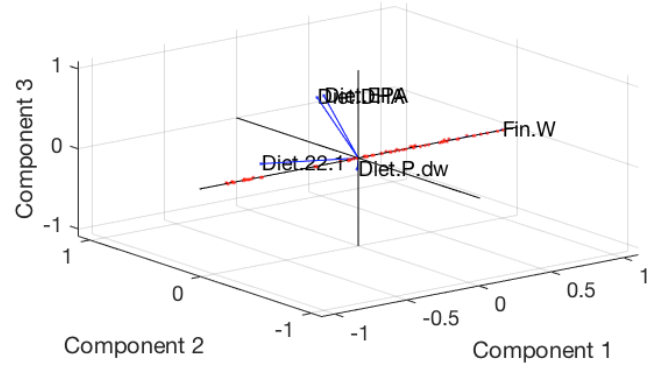


Figure 3

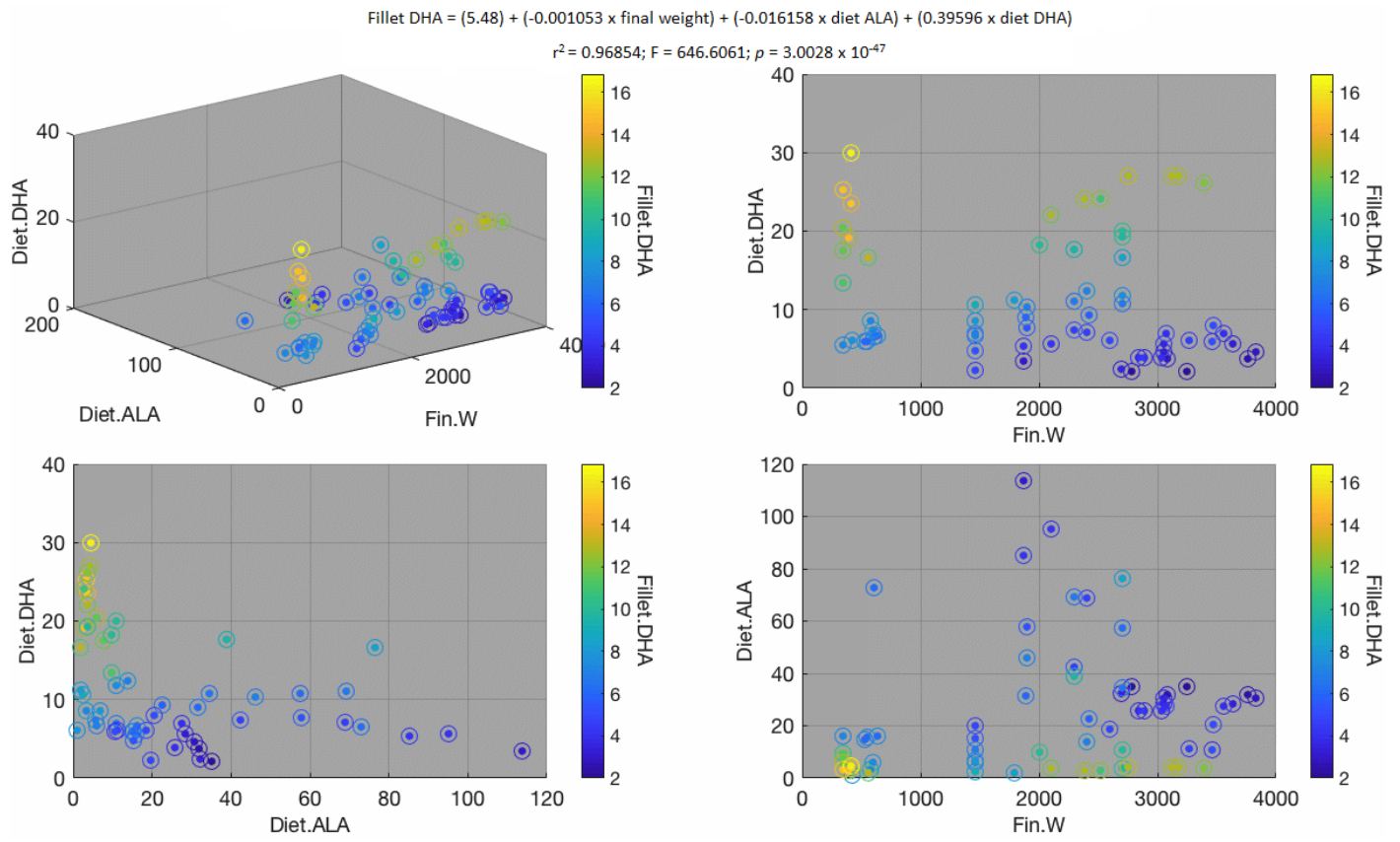


Figure 4



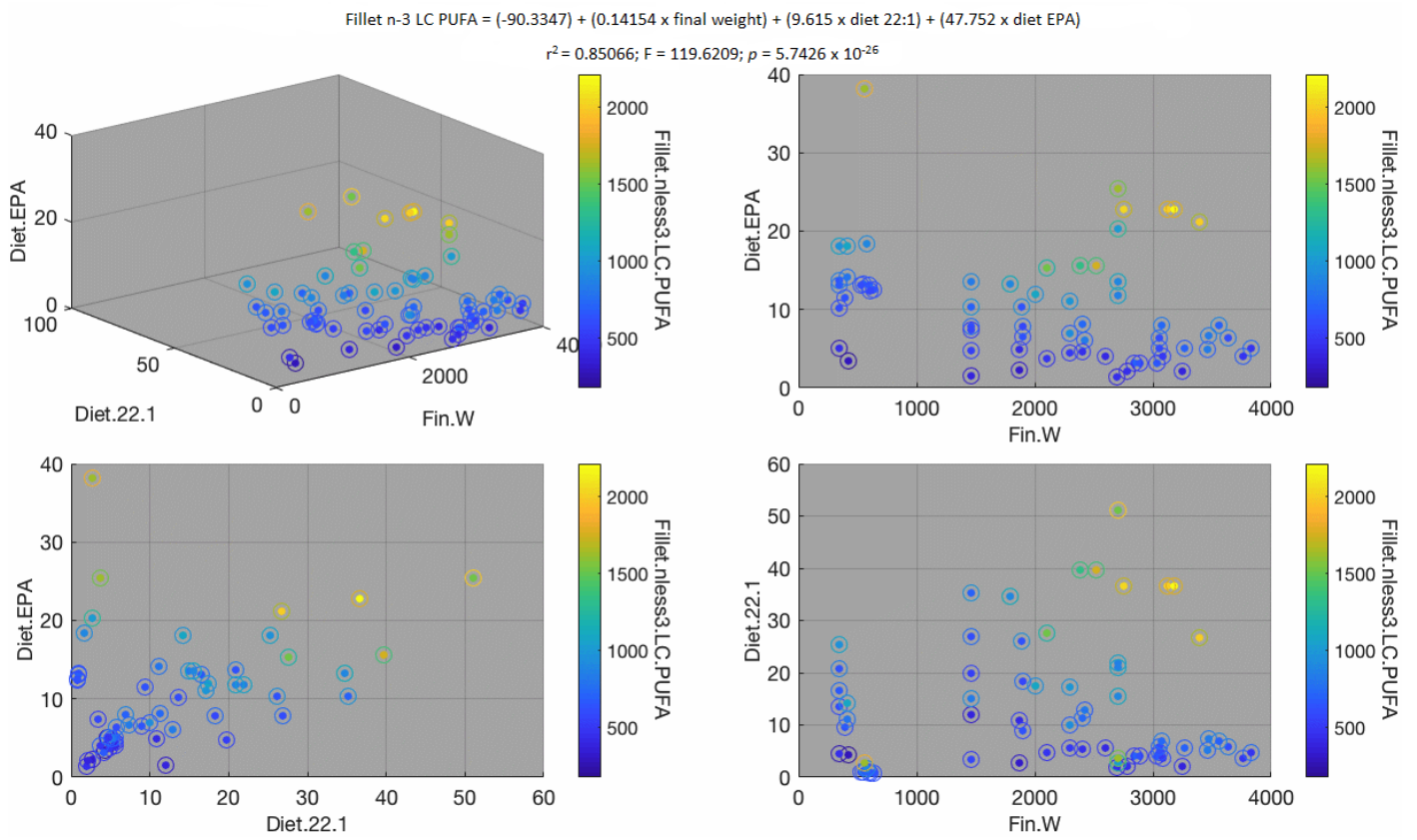


Figure 5