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## Geographic variation in stable isotopic and fatty acid composition of three families of anguilliform leptocephali and particulate organic matter (POM) in the western South Pacific

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2 **Geographic variation in stable isotopic and fatty acid composition**  
3 **of three families of anguilliform leptocephali**  
4 **and particulate organic matter (POM)**  
5 **in the western South Pacific**  
6  
7

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*Running Heading:* Variation in leptocephalus composition in western South Pacific.

47 **ABSTRACT:** The feeding ecology of leptocephali has remained poorly understood because  
48 they apparently feed on particulate organic matter (POM), which varies in composition, and it  
49 is unclear which components of the POM they assimilate. The  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  stable isotope  
50 (SI) and fatty acid (FA) compositions of 3 families of leptocephali and POM were compared in  
51 3 latitudinal current zones of the western South Pacific. The  $\delta^{15}\text{N}$  signatures of both  
52 leptocephali and POM overlapped, with both having their lowest values in the southern current  
53 zone. POM contained 38 FAs and was rich in saturated FAs (SFA) (16:0, 18:0, 14:0), while  
54 leptocephali contained 50 FAs, with high proportions of 16:0, and higher contributions of  
55 22:6 $\omega$ 3, 20:5 $\omega$ 3, 18:1 $\omega$ 9, 16:1 $\omega$ 7 and other FAs than the POM. Serrivomeridae leptocephali in  
56 the north had higher  $\delta^{15}\text{N}$  signatures and were also distinguished from Nemichthyidae and  
57 Muraenidae larvae by their FA compositions (higher SFAs, lower 22:6 $\omega$ 3 and 20:5 $\omega$ 3).  
58 Although SI signatures of the Serrivomeridae larvae did not clearly vary with size, 16:0 and  
59 18:0 FA proportions decreased with increasing larval size, and 22:6 $\omega$ 3 and 16:1 $\omega$ 7 increased in  
60 larger larvae. Correspondences between the latitudinal variations in nitrogen SI signatures and  
61 FA compositions of POM with those of leptocephali and the presence of FA markers of both  
62 autotrophic and heterotrophic organisms were consistent with leptocephali feeding on POM.  
63 POM can contain various materials from primary producers and heterotrophic microorganisms,  
64 but differences in the SI signatures and FA compositions in leptocephali remain to be  
65 explained through further research.

66

67 **KEYWORDS:** Leptocephali, fatty acids, stable isotopes, biomarkers, trophic ecology, oceanic  
68 currents.

69

## 70 **INTRODUCTION**

71 Leptocephali are the larvae of approximately 15 families of anguilliform fishes and  
72 their close relatives, which are widely distributed in the oceans from low-latitude temperate  
73 zones to tropical latitudes (Böhlke 1989, Miller & Tsukamoto 2004; Miller 2009). They have  
74 highly laterally-compressed, transparent bodies and a unique physiology compared to other  
75 fish larvae (Pfeiler 1999, Bishop et al. 2000). All eel families except the Anguillidae are  
76 almost exclusively marine and live in habitats ranging from the meso- and bathy- pelagic zones  
77 (*e.g.*, Nemichthyidae, Serrivomeridae) to coastal areas (*e.g.*, Muraenidae) (Miller & Tsukamoto  
78 2004). All leptocephali however, are present together in the near the surface to 300 m depth  
79 zone of oceanic areas (Castonguay & McCleave 1987, Miller 2009). Dependent on their taxa

80 and adult habitats, the pelagic phase lasts for several months to more than a year before the  
81 larvae undergo metamorphosis into juveniles (Marui et al. 2001).

82 Despite their wide distributions and the extensive literature on their morphology (*e.g.*,  
83 Böhlke 1989), the feeding ecology of leptocephali is still poorly resolved. During their larval  
84 feeding and growth period, leptocephali accumulate energy storage compounds such as lipids  
85 and glycosaminoglycans (GAG) in a gelatinous body matrix, which are then used for building  
86 new tissues during metamorphosis (Padrón et al. 1996, Pfeiler 1999, Pfeiler et al. 2002). A few  
87 studies have examined the gut contents of leptocephali and have observed materials that  
88 resemble particulate organic matter (POM) such as marine snow, discarded appendicularian  
89 houses or faecal pellets (Otake et al. 1993, Mochioka & Iwamizu 1996, Miller et al. 2011).  
90 Carbon and nitrogen stable isotope studies of leptocephali indicate they feed at a low trophic  
91 level (Otake et al. 1993, Miyazaki et al. 2011, Feunteun et al. 2015), which was confirmed  
92 using amino acid nitrogen isotopes (Miller et al. 2013).

93 Other observations have suggested that leptocephali might also feed on microplanktonic  
94 organisms such as protozoans (Tanaka et al. 1995, Govoni 2010) and the DNA sequences of  
95 various organisms including gelatinous zooplankton have been detected in leptocephalus  
96 stomach contents (Riemann et al. 2010). Marine snow however, can be composed of multiple  
97 materials and/or organisms, due to both aggregation and colonization processes (Alldredge &  
98 Silver 1988, Shanks & Walters 1997, Kjørboe 2000). Therefore, the hypothesis that  
99 leptocephali feed on POM and assimilate some of the components of marine snow, including  
100 colonising microorganisms, appears most likely (Deibel et al. 2012, Miller et al. 2013,  
101 Feunteun et al. 2015). Differences in the isotopic compositions of leptocephali taxa have been  
102 detected and clear correspondences between POM signatures and expected enrichment values  
103 in leptocephali have not always been observed (Miyazaki et al. 2011, Feunteun et al. 2015).  
104 Thus, it is unclear if leptocephali feed on POM opportunistically or if there are selective  
105 differences in the types of POM consumed and/or the types of compounds assimilated from  
106 ingested POM between different taxa.

107 An important component of the POM and organisms that potentially contribute to the  
108 diet of leptocephali are lipids, but only a few studies have examined the lipid content of  
109 leptocephali (Padrón et al. 1996, Deibel et al. 2012). Lipids are important for marine  
110 organisms because they are their major metabolic energy reserves (Falk-Petersen et al. 2000,  
111 Lee et al. 2006) and play key roles in cell structure and metabolism (Dalsgaard et al. 2003).  
112 Fatty acids (FAs) are a specific class of lipids that are energy rich molecules (Dalsgaard et al.

113 2003). Most consumers are unable to synthesize essential FAs (EFAs: 20:4 $\omega$ 6, 20:5 $\omega$ 3,  
114 22:6 $\omega$ 3), which are polyunsaturated FAs (PUFAs) with a terminal end omega-3 ( $\omega$ 3) or  
115 omega-6 ( $\omega$ 6), due to their lack of specific enzymes and therefore they acquire these EFA  
116 molecules exclusively from the food they eat (Canuel et al. 1995, Styrihave & Andersen 2000,  
117 Meziane et al. 2002, Dalsgaard et al. 2003).

118 Biochemical tracers such as FAs and stable isotope ratios (SI) are commonly used in  
119 trophic ecology studies because they provide information about the food sources that are  
120 assimilated by the organism over time (Pitt et al. 2009). SI ratios of carbon ( $\delta^{13}\text{C}$ ) and nitrogen  
121 ( $\delta^{15}\text{N}$ ) are used to evaluate the food sources of organisms (Fry & Sherr 1984, Canuel et al.  
122 1995) and to characterize organic matter transfer through food webs (Fry & Sherr 1984, Canuel  
123 et al. 1995, Abrantes & Sheaves 2009). FAs can be used as biomarkers of specific organisms  
124 (Meziane et al. 2007), or to determine the food sources exploited by consumer organisms  
125 (Meziane et al. 1997, Meziane & Tsuchiya 2000, Mortillaro et al. 2015). They can also be  
126 used to follow organic matter transfer through food webs (Dalsgaard et al. 2003, Budge et al.  
127 2006, Hall et al. 2006) and can provide information on larval ontogenetic changes (Plante et al.  
128 2006).

129 This study used bulk SI and FA composition to provide information on the possible  
130 food sources of leptocephali and was specifically intended to investigate: (1) How leptocephali,  
131 belonging to three families, may assimilate POM and the associated microorganisms  
132 colonizing POM (protozoa, microalgae, bacteria, etc.) (2) Whether the diet of leptocephali  
133 changes with size and/or with latitude and/or current systems in the western South Pacific  
134 Ocean?

135

## 136 **MATERIALS AND METHODS**

### 137 **Study area and sample collection**

138 Leptocephali were collected in the western South Pacific (WSP) during Leg 1 of the  
139 KH-13-2 research cruise of the research vessel (R/V) *Hakuho Maru* from 4–24 February 2013.  
140 Thirty-four stations were sampled at every 2° of latitude/longitude between 5°S–30°S and  
141 165°E–175°W, in the region that includes New Caledonia, Fiji and Samoa (Figure 1A).  
142 Leptocephali were collected using an Isaacs-Kidd midwater trawl (IKMT) with an 8.7 m<sup>2</sup>  
143 mouth opening and 0.5 mm mesh. Sampling at each station was conducted following two  
144 strategies: during the night a step tow fished in the upper 120 m (10 min. steps at 120 m, 70 m  
145 and 50 m), and during the day an oblique tow fished from the surface to 200 m, with both types

146 of tows taking less than 1 hour. Temperature, conductivity, depth (CTD) profiles were made at  
147 21 of the stations to a depth of 500 m.

148 Leptocephali from each IKMT sample were sorted fresh, measured and identified to the  
149 lowest possible taxonomic level according to Miller & Tsukamoto (2004). A total of 538  
150 leptocephali from 13 families were collected, but only the 3 most abundant families were  
151 analysed in this study. After identification and measurement, specimens to be used for SI and  
152 FA analyses were stored at  $-80^{\circ}\text{C}$ . In this study, family is the only taxonomic level considered,  
153 and 101 leptocephali from the 3 most abundant families; Muraenidae ( $n=27$ ; length 25.3–83.0  
154 mm,  $\text{mean}\pm\text{S.D.}= 50.1\pm 13.4$  mm), Nemichthyidae ( $n=28$ ; length 30.0–259.0 mm,  $122.0\pm 60.5$ )  
155 and Serrivomeridae ( $n=46$ ; length 9.2–62.0 mm,  $28.4\pm 14.4$  mm) were analysed for SI and FA  
156 composition (Figure 1). Five samples of the Serrivomeridae larvae samples consisted of 2 of  
157 the smallest larvae ( $< 10$  mm) pooled together to obtain enough tissue for analysis. Each  
158 leptocephalus specimen or pooled sample was used for both SI and FA analyses.  
159 Serrivomeridae larvae were used to examine differences in SI and FA composition in relation  
160 to leptocephalus size, because of the insufficient specimens of different sizes of Muraenidae  
161 and Nemichthyidae larvae, and the Serrivomeridae larvae were mostly from the same current  
162 zone.

163 Seawater samples were collected in triplicate at 13 stations (Figure 1A) in 12 L Niskin  
164 bottles attached to the CTD rosette multisampler at the depth of the chlorophyll maximum as  
165 measured by a fluorometer on the CTD were used for POM analyses. The depth of the  
166 chlorophyll maximum differed depending on the station, and was chosen because it is likely to  
167 have high concentrations of particulate material that may be suitable for feeding by  
168 leptocephali. No POM was sampled at the first CTD station in the southwest due to its  
169 proximity to the start of the cruise. POM was collected by filtering each 12 L of seawater  
170 sample through separate pre-combusted glass fibre filters (GF/F, 47 mm diameter,  $0.7\ \mu\text{m}$   
171 mesh). Large organisms such as copepods were removed manually and filters were  
172 immediately stored frozen at  $-80^{\circ}\text{C}$  until analysed.

173

#### 174 **Stable isotopes analysis**

175 All samples were lyophilised before analysis. GF/F filters were fumigated with 10%  
176 HCl for 4 h to remove inorganic carbon (Lorrain et al. 2003). Leptocephali samples were  
177 weighed. Carbon ( $^{13}\text{C}/^{12}\text{C}$ ) and nitrogen ( $^{15}\text{N}/^{14}\text{N}$ ) SI analysis were performed by the UC  
178 Davis Stable Isotope Facility (Department of Plant Sciences, University of California at Davis,

179 Davis, California) using a PDZ Europa ANCA-GSL elemental analyser for leptocephali  
180 analysis (half body, excluding the head region except for the smallest larvae) and an Elementar  
181 Vario EL Cube or Micro Cube elemental analyser (Elementar Analysensysteme GmbH, Hanau,  
182 Germany) for the GF/F filter POM samples (half filter). Each elemental analyser was  
183 interfaced to a PDZ Europa 20-20 isotope ratio mass spectrometer (Sercon Ltd., Cheshire,  
184 UK). Isotopic data are reported using standard delta notation ( $\delta^{13}\text{C}$  or  $\delta^{15}\text{N}$ ), defined as parts  
185 per thousand deviation (‰) from an international standard (Vienna Peedee belemnite for  $\delta^{13}\text{C}$   
186 and atmospheric  $\text{N}_2$  for  $\delta^{15}\text{N}$ ) as defined by the equation:

$$187 \quad \delta^{13}\text{C} \text{ or } \delta^{15}\text{N} = [(R_{\text{sample}}/R_{\text{standard}}) - 1] \times 1000$$

188

189 Where  $R = {}^{15}\text{N}/{}^{14}\text{N}$  or  ${}^{13}\text{C}/{}^{12}\text{C}$  of the sample or standard (Peterson & Fry 1987). The  
190 analytical precision (standard deviation for repeated measurements of internal standards) was  
191  $\pm 0.2\text{‰}$  and  $\pm 0.3\text{‰}$  for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ , respectively. All mean values of SI and FA data are  
192 expressed as mean  $\pm$  standard deviation (S.D.).

193

#### 194 **Fatty acid analysis**

195 Lipids were extracted following Meziane et al. (2007). Briefly, lipid samples (half  
196 bodies or filters) were extracted twice with a mixture of distilled water, MeOH and  $\text{CHCl}_3$   
197 (1:2:1, v:v:v). Saponification and methylation were performed successively under reflux  
198 according to Meziane & Tsuchiya (2000). Saponification was achieved using a 2 M  
199 NaOH:MeOH solution (1:2, v:v) and methylation with 1 ml of 14%  $\text{BF}_3$ -MeOH. The fatty  
200 acid methyl esters (FAMES) were separated and quantified by Gas Chromatography (Varian  
201 CP-3800) using a flame ionisation detector at the National Museum of Natural History  
202 (MNHN-Paris, Resaqua Laboratory). Separation was performed with an Agilent J&W GC  
203 VF-WAXms column (30 m x 0.25 mm i.d.; 0.25  $\mu\text{m}$  film thickness) with He as carrier gas.  
204 Most of FAs peaks were identified by comparing their retention times with those of known  
205 standards (Supelco<sup>TM</sup> 37 FAME mix; Sigma-Aldrich<sup>®</sup>) and confirmed with a GC-mass  
206 spectrometer (Varian 450-GC 220-Ion Trap MS; He as carrier gas). FAs are designated as  
207 X:Y $\omega$ Z, where X is number of carbon atoms, Y is number of double bonds and Z is the  
208 position of the ultimate double bond with respect to the terminal methyl group. The  
209 concentration of each FA was calculated using 23:0 as an internal standard according to  
210 Schomburg (1987):  $C_{\text{FA}} = A_{\text{S}}/A_{\text{IS}} \times C_{\text{IS}}/W_{\text{S}}$ , where  $A_{\text{S}}$  is the peak area of the FA,  $A_{\text{IS}}$  the peak



211 area of the internal standard,  $C_{IS}$  the concentration of the standard and  $W_S$  the dry weight of  
212 sample.

213

#### 214 **Latitudinal regions of the study area**

215 The study area was located within the northwestern part of the WSP subtropical gyre  
216 (Qiu & Chen 2004). The water temperature in this region decreases from the north to south  
217 (Miller et al. 2006) and during the survey it ranged from 29°C (surface) and 21–23°C (200 m)  
218 at northern stations (8°N) to 25°C and 18°C respectively in the south (24°S). This region  
219 includes 3 main surface currents at different latitudes, which are the westward South Equatorial  
220 Current (SEC, Equator to 20°S), the narrow eastward South Equatorial Countercurrent (SECC)  
221 at 5 to 10°S (between two branches of the SEC), and the eastward South Tropical  
222 Countercurrent (STCC) at latitudes south of Fiji and north of New Zealand (Qiu & Chen 2004;  
223 Ganachaud et al. 2014). The SECC was present north of 10°S according to ADCP  
224 observations made during the cruise, with mixed westward flow at central latitudes and mixed  
225 eastward flow in the south (Otake et al. unpubl. cruise report). The assemblages of  
226 leptocephali vary latitudinally in this region, with Serrivomeridae larvae being most abundant  
227 in the north, species such as Muraenidae being abundant at central latitudes, and  
228 Nemichthyidae being more equally distributed across latitudes (Miller et al. 2006) as they were  
229 during the present survey (Figure 1B-D). According to the general pattern of currents, the  
230 cruise stations were separated into 3 latitudinal zones for analyses of SI and FA compositions  
231 of leptocephali and POM, which generally correspond with the SECC, SEC, and STCC current  
232 systems (Figure 1B).

233

#### 234 **Data analysis**

235 All SI and FA data are expressed as mean values  $\pm$  standard deviation (S.D.). Prior to  
236 statistical comparison, data were first evaluated for homocedasticity (Bartlett test) and  
237 normality of distribution (Shapiro-Wilk test), which were not attained in most cases.  
238 Therefore, non-parametric Kruskal-Wallis (KW) tests were used to compare FA and SI group  
239 values, followed by pairwise comparisons with Mann–Whitney Wilcoxon (MWW) tests and  
240 Bonferroni correction to correct significance thresholds. When the sample size in a current  
241 zone was too low, only KW tests were used.

242 All FAs were used in the analyses and no transformations were performed on the  
243 dataset to prevent excessive weighting of low proportion FAs. Data matrices (% TFA per

244 sample) were used to create triangular dissimilarity matrices with the Bray-Curtis dissimilarity  
245 coefficient, followed by non-metric multidimensional scaling (n-MDS). Stress values < 0.2  
246 were considered robust (Clarke 1993). Groups used as factors for the analysis were family  
247 (Muraenidae, Nemichthyidae, Serrivomeridae) and size groups ( $\leq 10.0$ , 10.1–20.0, 20.1–40.0,  
248 40.1–60.0 mm, Serrivomeridae only), as well as current zones (SEC, SEC, STCC) for both  
249 leptocephali and POM. Differences in FAs composition among groups was statistically tested  
250 using separate one-way analysis of similarity (ANOSIM) computed after 5000 permutations.  
251 Average dissimilarity (AD) between groups was determined by SIMilarity of PERcentage  
252 (SIMPER) analysis (PRIMER<sup>®</sup>5 software module) was used to identify which fatty acids  
253 determine the observed differences within or between groups.

254 Multivariate analyses were performed with PRIMER<sup>®</sup>5 software (Clarke & Warwick,  
255 2001) and univariate tests using R software (R development Core Team 2014, Vegan package,  
256 Oksanen et al. 2014). For all univariate tests, the probability  $\alpha$  was set at 0.05.

257

## 258 **RESULTS**

### 259 **Isotopic and fatty acids composition of Particulate organic matter and leptocephali**

260

261 **Particulate organic matter (POM).** SI values of POM (Figure 2) ranged from -27.8‰  
262 to -25.0‰ for  $\delta^{13}\text{C}$  (mean $\pm$ S.D. = -26.6 $\pm$ 0.7‰) and from 2.5‰ to 10‰ for  $\delta^{15}\text{N}$  (6.1 $\pm$ 2.3‰)  
263 (Table 1). A total of 38 FAs were identified in the POM (Table 1). Average saturated fatty  
264 acid (SFAs) contribution to POM was 75.2 $\pm$ 4.6% of total FAs, with 16:0 showing the highest  
265 contribution (35.9 $\pm$ 2.3%). The main monounsaturated fatty acids (MUFAs) were 18:1 $\omega$ 9  
266 (5.3 $\pm$ 1.1%) and 16:1 $\omega$ 7 (4.4 $\pm$ 0.9%). All relative contributions of polyunsaturated fatty acids  
267 (PUFAs) were low with maximum values of 1.7 $\pm$ 0.4% for 16:2 $\omega$ 4, 1.7 $\pm$ 0.8% for 22:6 $\omega$ 3 and  
268 1.7 $\pm$ 0.5% for 18:4 $\omega$ 3. Similarly, EFAs 20:5 $\omega$ 3 and 20:4 $\omega$ 6 had low contributions to TFAs  
269 (about or  $\leq$  1%). Contributions of branched-chain fatty acid (BrFAs) were 2.4 $\pm$ 0.4% of TFAs.

270 **Leptocephali.** For the 3 families of leptocephali (Figure 2),  $\delta^{13}\text{C}$  stable isotope values  
271 ranged from -23.1‰ to -18.8‰ and from 0.7‰ to 14.5‰ for  $\delta^{15}\text{N}$  (Table 1). There was a  
272 significant difference in  $\delta^{13}\text{C}$  composition between Serrivomeridae (-21.0 $\pm$ 0.8‰) and  
273 Nemichthyidae (-19.9 $\pm$ 0.8‰) leptocephali (KW:  $p < 0.001$ ; followed by MWW:  $p < 0.001$ ).  
274  $\delta^{15}\text{N}$  signatures were significantly different among each of the 3 families (KW:  $p < 0.001$ ;  
275 MWW:  $p < 0.01$ ) with an average  $\delta^{15}\text{N}$  of 4.7 $\pm$ 3.3‰ for Nemichthyidae, 6.7 $\pm$ 2.7‰ for  
276 Muraenidae and 10.9 $\pm$ 1.9‰ for Serrivomeridae.

277 A total of 50 FAs was identified in leptocephali (Table 1), with a large contribution of  
278 SFAs, MUFAs, and PUFAs to TFAs. The same 6 FAs (16:0, 16:1 $\omega$ 7, 18:0, 18:1 $\omega$ 9, 20:5 $\omega$ 3  
279 and 22:6 $\omega$ 3) were most abundant in all 3 families, with all the other FAs each contributing less  
280 than about 4% to the TFAs. Muraenidae had higher levels of FAs by weight ( $11.7\pm 7.4$  mg g<sup>-1</sup>)  
281 than Nemichthyidae ( $5.2\pm 2.5$  mg g<sup>-1</sup>) and Serrivomeridae ( $5.4\pm 4.0$  mg g<sup>-1</sup>).

282 The 3 families also showed differences regarding their FAs compositions (ANOSIM:  
283  $p<0.001$ ), with Muraenidae showing no overlap with the Serrivomeridae and Nemichthyidae,  
284 which overlapped to some degree in the n-MDS plot (Figure 3). FAs profiles of leptocephali  
285 exhibited average dissimilarity values (AD; SIMPER analysis) that were more similar between  
286 Muraenidae and Serrivomeridae (16.6%) than between Muraenidae and Nemichthyidae  
287 (14.3%) and between Nemichthyidae and Serrivomeridae (14.6%). The observed differences  
288 were mostly due to the relative contributions of 16:0, 16:1 $\omega$ 7, 18:0, 18:1 $\omega$ 9, 20:5 $\omega$ 3 and  
289 22:6 $\omega$ 3 to TFAs (Table 1). SFAs contributed a higher proportion of TFAs in Serrivomeridae  
290 leptocephali ( $44.8\pm 7.5\%$ ) than PUFAs ( $33.8\pm 5.7\%$ ), whereas the PUFAs contribution was  
291 slightly higher in Muraenidae and Nemichthyidae ( $42.3\pm 3.7\%$  and  $39.4\pm 4.2\%$ , respectively)  
292 than SFAs contribution ( $38.5\pm 3.7\%$  and  $37.4\pm 4.2\%$ , respectively) (Figure 4A,B). The total  $\omega$ 3  
293 FAs contribution were significantly different (KW:  $p<0.001$ ; MWW:  $p<0.05$ ) for the 3  
294 families, ranging from  $23.7\pm 5.5\%$  for Serrivomeridae to  $32.5\pm 3.8\%$  for Muraenidae (Figure  
295 4C). BrFAs contributed less than 1% of TFAs, but differed significantly in their contribution  
296 to TFAs (KW:  $p<0.001$ ; MWW:  $p<0.001$ ) between Muraenidae ( $0.5\pm 0.1\%$ ) and the other  
297 families (Nemichthyidae:  $0.8\pm 0.1\%$  and Serrivomeridae:  $0.9\pm 0.2\%$ ) (Figure 4D).

298 Fatty acid trophic markers (FATMs) of the leptocephali included two predominant 16:0  
299 and 22:6 $\omega$ 3 FAs, which contributed on average 40% of the TFAs (Table 1). Proportions of the  
300 PUFAs 20:5 $\omega$ 3 and 22:6 $\omega$ 3 were lower for Serrivomeridae ( $5.1\pm 2.1\%$  and  $14.8\pm 3.2\%$ ,  
301 respectively) than for the two other families (KW  $p<0.001$ ; MWW:  $p<0.001$ ). Muraenidae had  
302 the highest percentage of 22:6 $\omega$ 3 of the 3 families. The contribution of 18:1 $\omega$ 9 to TFAs was  
303 lower for Muraenidae ( $5.8\pm 0.9\%$ ; KW:  $p<0.001$ ; MWW:  $p<0.001$ ) than Nemichthyidae and  
304 Serrivomeridae ( $8.3\pm 1.7\%$  and  $8.8\pm 1.3\%$ , respectively).

305

### 306 **FA compositions and SI signatures of Serrivomeridae size groups**

307 The 4 size groups of Serrivomeridae leptocephali were compared for their FAs and SI  
308 signatures. No significant differences were found between size groups for  $\delta^{15}\text{N}$  (Table 2) and

309  $\delta^{13}\text{C}$  values were only significantly different for  $\leq 10$  mm larvae ( $-19.9 \pm 0.6\text{‰}$ ) and 40–60 mm  
310 larvae ( $-21.4 \pm 0.5\text{‰}$ ) (KW:  $p < 0.01$ ; MWW:  $p < 0.05$ ).

311 The FA compositions of the Serrivomeridae leptocephali showed various percentage  
312 changes with increasing size, with SFAs and BrFAs tending to decrease, and MUFAs and  
313 PUFAs tending to increase with increasing leptocephali size (Table 2). The total weight of FA  
314 in the body of the leptocephali tended to decrease only slightly from the smallest to largest size  
315 classes ( $5.8$  to  $4.4 \text{ mg g}^{-1}$ ) but differences were not significant. The 40–60 mm and  $\leq 10$  mm  
316 sizes classes were significantly different in FA composition (ANOSIM:  $p < 0.05$ ; n-MDS),  
317 Figure 5) with an AD of 23.2%. The SFAs contribution to  $\leq 10$  mm larvae was higher  
318 ( $56.7 \pm 0.9\%$ ) and PUFAs contribution was lower ( $25.2 \pm 0.6\%$ ) than in 40–60 mm larvae  
319 ( $37.1 \pm 0.3\%$  for SFAs and  $39.0 \pm 0.4\%$  for PUFAs) mainly due to the contribution of the SFAs  
320 16:0 and 18:0, the MUFA 16:1 $\omega$ 7 and the PUFAs 22:6 $\omega$ 3 and 20:5 $\omega$ 3 (Table 2). The  
321 contribution of  $\omega$ 3 FAs increased with size, from  $16.4 \pm 1.0\%$  for  $\leq 10$  mm to  $30.0 \pm 0.7\%$  for 40–  
322 60 mm larvae.

323

#### 324 **POM and leptocephali SI signatures in current zones**

325 The POM exhibited variation in  $\delta^{15}\text{N}$  values, which ranged from  $7.7 \pm 2.3\text{‰}$  in the  
326 SECC in the north, to  $4.1 \pm 1.0\text{‰}$  in the STCC in the southeast (Table 3), although the SEC  
327 values overlapped with those of the other zones (Figure 6D). The  $\delta^{13}\text{C}$  values showed less  
328 variation with mean values that ranged from  $-27.0 \pm 0.2\text{‰}$  to  $-26.2 \pm 0.9\text{‰}$ , but some of the  
329 SECC values were lower (Figure 6D). When FA compositions of POM were separated  
330 according to the 3 current zones, samples from the SECC ( $5\text{--}15^\circ\text{S}$ ) were significantly different  
331 (ANOSIM:  $p < 0.05$ ) from those of both the SEC ( $15\text{--}20^\circ\text{S}$ ) and STCC ( $20\text{--}30^\circ\text{S}$ ) with an AD  
332 of 12.5% between the SECC and SEC, and 13.2% between SECC and STCC. These  
333 differences mostly resulted from variations in the proportions of the SFAs 18:0, 16:0 and 14:0  
334 (AD between 1.4 and 2.6%), the MUFAs 18:1 $\omega$ 9 and 16:1 $\omega$ 7 (AD between 0.9 and 0.7%) and  
335 PUFAs 22:6 $\omega$ 3 and 18:4 $\omega$ 3 (AD between 0.8 and 0.5%). In the SECC, the SFA contribution  
336 was higher ( $78.8 \pm 3.9\%$ ) and MUFA and PUFA contributions lower ( $11.7 \pm 2.9\%$  and  $7.1 \pm 1.4\%$ )  
337 than in the other zones (Table 3).

338 Leptocephali also showed differences in isotopic signatures between the 3 current  
339 zones, with  $\delta^{15}\text{N}$  values being different (KW and MWW:  $p < 0.05$ ). Some separation of the  
340  $\delta^{15}\text{N}$  signatures in the 3 zones was also seen within families, except there was only one  
341 Serrivomeridae larva analysed from the STCC (Figure 6A-C). For Serrivomeridae

342 leptocephali there was no significant difference in  $\delta^{13}\text{C}$  values between larvae caught in the  
343 different current zones, whereas  $\delta^{15}\text{N}$  signatures were different between larvae from the SECC  
344 and SEC (t-test:  $p < 0.05$ ) (Figure 6C). Muraenidae from the SEC and SECC had different in  
345 both their  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values (KW and MWW:  $p < 0.05$ ) (Figure 6B). There were also  
346 differences in the  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  signatures of Nemichthyidae found in the STCC and those in  
347 the SECC and SEC, respectively (KW and MWW:  $p < 0.05$ ) (Figure 6A). FA profiles for the  
348 leptocephali caught in the three different currents were not significantly different (KW and  
349 MWW:  $p > 0.1$ ).

350

## 351 **DISCUSSION**

### 352 **FA and SI signatures of leptocephali and POM**

353 This study examined the variation of the FA profiles and SI signatures of 3 families of  
354 leptocephali and their likely food source of POM. Samples were collected across a wide range  
355 of latitudes and longitudes of the WSP. Previous studies in the western North Pacific  
356 (Miyazaki et al. 2011) and western Indian Ocean (Feunteun et al. 2015) analysed leptocephali  
357 and POM from much more limited areas of the ocean.

358 The chemical composition of the different taxa of leptocephali is generally comparable  
359 (Pfeiler 1999, Bishop et al. 2000) as confirmed by the FA profiles of the 3 families of  
360 leptocephali studied in the WSP that show many similarities. There were however, also some  
361 differences. The Nemichthyidae, Muraenidae, and Serrivomeridae larvae had the same number  
362 of major FAs and categories of FAs markers showed similar proportions. Deibel et al. (2012)  
363 also found similar FA compositions for 6 other taxa of leptocephali (Congridae,  
364 Muraenesocidae, Ophichthidae) from coastal, shelf or deep slope habitats off northwest  
365 Australia. However, despite these overall similarities, the present study found small but  
366 significant differences between the FA profiles of Muraenidae larvae and those of  
367 Nemichthyidae and Serrivomeridae. The similarities in FAs compositions of the 3 families  
368 were largely due to the FAs that were present in large proportions: 16:0, 18:0, 22:6 $\omega$ 3, 20:5 $\omega$ 3,  
369 16:1 $\omega$ 7, and 18:1 $\omega$ 9. The same 6 FAs also had the highest proportions in leptocephali from  
370 northwestern Australia (Deibel et al. 2012).

371 SFAs 16:0 and 18:0 (mean ~24% and 8% of TFAs in all 3 families of leptocephali) are  
372 the most abundant FAs in nature as they are products of lipogenesis in all organisms (Dewick  
373 1997). Similarly,  $\omega$ 3 FAs are abundant in marine zooplankton (Lee et al. 2006) and fish larvae  
374 (Grote et al. 2011), as they were in the leptocephali, where they represented 24 to 33% of total

375 FAs depending on family. Amongst  $\omega 3$ , the EFAs 20:5 $\omega 3$  and 22:6 $\omega 3$  are major components  
376 of cell membrane phospholipids (Sargent et al. 1993) and are also important for larval growth  
377 and development (Sargent et al. 1993, Furuita et al. 2006, Grote et al. 2011). Marine  
378 consumers however, cannot synthesize essential  $\omega 3$  and  $\omega 6$  PUFAs (Dalsgaard et al. 2003, Lee  
379 et al. 2006, Kattner et al. 2007) so they need to obtain them through feeding (Canuel et al.  
380 1995, Styrishave & Andersen 2000, Meziane et al. 2002). Thus, high proportions of  $\omega 3$  and  
381  $\omega 6$  in leptocephali suggest that leptocephali feed on material containing or originating from  
382 autotrophic organisms or primary consumers in which  $\omega 3$  and  $\omega 6$  are abundantly present (Scott  
383 et al. 2002, Dalsgaard et al. 2003, Lee et al. 2006). There is also the possibility that  
384 leptocephali, as do some heterotrophic organisms (Dalsgaard et al. 2003, Canuel et al. 1995),  
385 synthesize these FAs from a precursor such as 18:1 $\omega 9$ . This MUFA is abundant in  
386 leptocephali (mean of  $7.6 \pm 1.6\%$  for the 3 families combined in this study, and  $6.4 \pm 1.3\%$  in  
387 Deibel et al. 2012) and can be obtained from feeding on zooplankton or other heterotrophic  
388 sources in pelagic food webs (Dalsgaard et al. 2003, Lee et al. 2006).

389 In this study, POM was characterized by a strong contribution of SFAs (~75% of TFAs)  
390 and a low contribution of  $\omega 3$  (~5%), MUFAs (~13%) and PUFAs (~9%), which typically  
391 indicates a low nutritional quality for the bulk organic matter, as suggested by other studies in  
392 diverse aquatic systems (*e.g.*, North Sea, Boon & Duineveld 1996; Amazon River, Mortillaro  
393 et al. 2011). Interestingly, the important FATMs 18:1 $\omega 9$  and 16:1 $\omega 7$  (markers of heterotrophs  
394 and autotrophic microplankton, respectively) were the main unsaturated FAs that contributed  
395 to the TFAs of POM (~5 and 4%, respectively). Also, BrFA markers made a low contribution  
396 to TFAs (~2%) in POM. Most of these FATMs are typically biosynthesized in large amounts  
397 by bacteria (Kaneda 1991, Ederington et al. 1995, Meziane & Tsuchiya 2000) and because  
398 decaying bulk POM is rapidly colonised by bacteria (Skerratt et al. 1995, Najdek et al. 2002), it  
399 would be expected to be rich in these BrFAs. Thus, the FA composition may indicate that the  
400 POM sampled within the chlorophyll maximum layer during this study is likely to be  
401 composed of a large non-living POM fraction (detritus, faecal pellets, etc.) with a low bacterial  
402 influence and to a lesser extent of living organic material (autotrophic and heterotrophic  
403 microplankton) that leptocephali would preferentially assimilate.

404 The diet of an organism can usually be examined by assuming a mean isotopic trophic  
405 enrichment of 1‰ in  $\delta^{13}\text{C}$  (DeNiro & Epstein 1978, Rau et al. 1983) and of 3.4‰ in  $\delta^{15}\text{N}$   
406 (DeNiro & Epstein 1981, Minagawa & Wada 1984) from food source to consumer. The  $\delta^{15}\text{N}$   
407 values of POM (2.5 to 12‰) and leptocephali (0.5 to 13‰) in the present study heavily

408 overlapped, so no clear trophic enrichment between  $\delta^{15}\text{N}$  signatures of POM and leptocephali  
409 was evident, except perhaps for Serrivomeridae. One explanation for this is that there could be  
410 a mismatch between the POM sampled on the filters and the types of POM that leptocephali  
411 consume and what they assimilate from this, as mentioned above and described further below.  
412 A similar result was also described by Otake et al. (1993), who found that the  $\delta^{15}\text{N}$  signature of  
413 Congridae leptocephali (*Conger myriaster*) overlap with that of POM (~11–13‰). A wide  
414 range of POM  $\delta^{15}\text{N}$  values overlapping with those of leptocephali was also seen in studies in  
415 the western North Pacific (Miyazki et al. 2011) and western Indian Ocean (Feunteun et al.  
416 2015). Other studies examining geographic variations in SI signatures of POM and organisms  
417 found similarly high values of  $\delta^{15}\text{N}$  for POM (Waite et al. 2007, Lorrain et al. 2015). This is  
418 presumably a result of regional variations that occur globally in the  $\delta^{15}\text{N}$  values of primary  
419 producers that contribute to POM, with some areas such as parts of the South Pacific likely  
420 having higher values than other regions of the world (Somes et al. 2010). The  $\delta^{13}\text{C}$  gap of  
421 about 7‰ between mean values (2‰ gap for closest values) of POM and leptocephali is also  
422 clearly larger than the expected 1‰ gap if leptocephali were consuming POM within the  
423 chlorophyll maximum and assimilating all of it. The values of  $\delta^{13}\text{C}$  of the POM we collected  
424 within the chlorophyll maximum (about -25 to -27‰) were lower than those usually reported  
425 for oceanic environments (e.g. Waite et al. 2007, Hwang et al. 2009, Miyazki et al. 2011).  
426 However, values of  $\delta^{13}\text{C}$  of bulk POM as low as -25 to -29‰ have been reported at similar  
427 depths in several offshore areas (Jeffrey et al. 1983, Durffel et al. 2003, Feunteun et al. 2015,  
428 Soares et al 2015). These low  $\delta^{13}\text{C}$  bulk POM values are measured within or just below the  
429 depth of the chlorophyll maximum and this may be a common pattern in the open ocean  
430 (Jeffrey et al. 1983, Durffel et al. 1998, Hwang et al. 2009, Close et al. 2014). Moreover, POM  
431 is considered to be organic material that usually forms bigger particles commonly called  
432 “marine snow” that contains various living organisms (Alldredge & Silver 1988, Shanks &  
433 Walters, 1997, Kjørboe, 2000). Therefore, bulk POM composition in the open ocean likely  
434 depends on plankton communities but also on the non-living degraded part of the organic  
435 matter as well as bacterial communities. Isotopic fractionation and thus the signature of the  
436 bulk POM can differ due to variations in physiological processes between phytoplanktonic  
437 groups (metabolic  $^{13}\text{C}$  enrichment, C-fixation) that are related to cell size, physiology and  
438 growth rate (Goericke & Fry 1994, Popp et al. 1998). POM with widely varying  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$   
439 signatures can be found at different depths (Jeffrey et al. 1983, Waite et al. 2007, Miyazki et al.  
440 2011, Feunteun et al. 2015), so our POM isotopic values may be related to the specific

441 signatures within the chlorophyll maximum, which is not targeted in studies that only sample at  
442 particular depths. Or they could be partly related to aspects of the biological communities in  
443 our study area, which have not yet been studied. These factors might explain the large range of  
444 values in carbon and nitrogen signatures of POM in the WSP.

445 It is also possible that leptocephali do not feed exclusively within the chlorophyll  
446 maximum or consume every type of POM. It is more likely that leptocephali select specific  
447 types of POM particles to eat, such as some types of marine snow or the appendicularian  
448 houses that have been directly observed in the intestines of leptocephali (Mochioka and  
449 Iwamizu 1996, Miller et al. 2011). In addition, some materials such as zooplankton faecal  
450 pellets observed in gut contents (Otake et al. 1993, Miller et al. 2011) are unlikely to be  
451 digested. Further differences between the SI signatures of the POM sample collected on a  
452 filter and those that leptocephali consume and assimilate might be related to the transparent  
453 exopolymer particles (*i.e.* TEP; Passow 2002) produced by microorganisms (phytoplankton,  
454 bacteria) that aggregate within POM. TEPs are mainly composed of carbohydrate molecules  
455 that aggregate into marine snow (Holloway and Cowen 1997, Skoog et al. 2008, Engel et al.  
456 2012) and are at the interface between dissolved and particulate organic carbon (Passow 2002).  
457 Therefore, a significant fraction of TEP is likely not retained on the GF/F filters used to collect  
458 POM from the water samples, leading to these compounds being only partially included in  
459 POM carbon measurements; whereas they would have been present in the POM materials  
460 assimilated by leptocephali. In addition, carbohydrates are molecules having no nitrogen, only  
461 the  $\delta^{13}\text{C}$  signature of these compounds would be reflected in leptocephali if they were  
462 assimilated (Feunteun et al. 2015). Also, leptocephali have a long larval duration, so as  
463 previous studies have pointed out, larger larvae could be transported into collection areas after  
464 originating from other areas where they have fed on POM with different isotopic signatures  
465 (Myazaki et al. 2011, Feunteun et al. 2015).

466

### 467 **Feeding ecology of leptocephali**

468 Considering the various possible factors discussed above, the SI and FA analyses of this  
469 study may still be generally consistent with the hypothesis that leptocephali feed on POM,  
470 which has been indicated by direct observations of their gut contents (Otake et al. 1993, Miller  
471 et al. 2011) and an analysis of their trophic position (Miller et al. 2013). The observational  
472 studies of the gut contents of leptocephali that have found POM components such as  
473 amorphous materials, appendicularian and other zooplankton fecal pellets, and discarded



474 appendicularian houses (Otake et al. 1993, Mochioka & Iwamizu 1996, Miller et al. 2011),  
475 provide direct evidence of POM consumption by a variety of eel larvae taxa. Also, Feunteun et  
476 al. (2015) characterised SI signatures of many taxa of zooplankton along with 12 taxa of  
477 leptocephali and POM and did not find evidence of leptocephali feeding on zooplankton.  
478 However, as in previous SI studies (Miyazaki et al. 2011, Feunteun et al. 2015) it remains  
479 unclear what types and components of POM are used by various taxa of leptocephali, and  
480 methodological issues related to the filtration and analysis of POM may make it difficult to see  
481 clear linkages using SI analyses.

482 The FATM compositions determined in the present study and those of Deibel et al.  
483 (2012) indicate that leptocephali obtain their nutrition from various sources that include both  
484 phytoplankton (16:1 $\omega$ 7, 20:5 $\omega$ 3), dinoflagellates (22:6 $\omega$ 3) and heterotrophic microorganisms  
485 such as bacteria and protozoans (18:1 $\omega$ 9) (Dalsgaard et al. 2003), all of which are likely to  
486 contribute to POM composition (Alldredge & Silver 1988, Shanks & Walters, 1997, Kiørboe,  
487 2000). As explained above and also suggested in other studies (Dalsgaard et al. 2003, Pitt et al.  
488 2009), the composition of the food contents in the intestines of leptocephali could be different  
489 from what they assimilate from ingested food. Our FA results suggest that it is the materials  
490 from living organisms associated with POM that are mainly assimilated by leptocephali (*e.g.*  
491 FATM of autotrophic and heterotrophic organisms). Indeed, Muraenidae larvae were rich in  
492 PUFAs and  $\omega$ 3 meaning even they feed on FA poor food source, they are able to preferentially  
493 assimilate and store FAs-rich components of the POM. Conversely, Serrivomeridae larvae had  
494 the highest SFA and lowest PUFAs and  $\omega$ 3 proportions, which suggests that they may feed on  
495 POM opportunistically, with no selective assimilation or FA storage.

496

#### 497 **FA and SI composition of Serrivomeridae size classes**

498 Although no major differences were found in the isotopic compositions of the 4 size  
499 classes of Serrivomeridae leptocephali, clear changes in their FA composition were detected.  
500 The only significant SI differences were that  $\delta^{13}\text{C}$  values differed between the largest (-21.4‰)  
501 and smallest (-19.9‰) size classes, but no significant differences were found in  $\delta^{15}\text{N}$  values.  
502 In contrast, all the major categories of FAs showed at least minor changes with size, either  
503 increasing MUFA and PUFA or decreasing SFA contributions to TFAs.

504 The dynamic nature of lipid metabolism and the influence of dietary lipids when larvae  
505 first feed can cause FA composition shifts during ontogeny (Wiegand 1996, Rainuzzo et al.  
506 1997, Plante et al. 2006, Grote et al. 2011), and shifts in the growth strategies of leptocephali

507 when they reach large sizes may result in physiological changes (Pfeiler 1999, Bishop et al.  
508 2000). The decrease in percentage of SFAs in larger Serrivomeridae larvae might be caused by  
509 16:0 and 18:0 being used as a major substrates for energy production (Sargent 1995). MUFAs  
510 and PUFAs are energy sources for development and growth especially during the larval stage  
511 when fish need energy for organogenesis, fast growth and basal metabolism (Abi-ayad et al.  
512 2004, Plante et al. 2006) and these tended to increase in proportion in the leptocephali.  
513 Moreover, the PUFA 20:5 $\omega$ 3 is an important energy substrate, as well as the 22:6 $\omega$ 3, which is  
514 also one of the principal components of cell membranes (Dalsgaard et al. 2003). In  
515 Serrivomeridae, the increase of MUFAs and PUFAs percentages with size suggest that these  
516 energetically rich FAs are not preferentially used to provide energy during larval growth. Thus,  
517 larvae may be preferentially storing energy dense FAs such as long chain FAs and PUFAs that  
518 they cannot synthesize and which are in low concentrations in POM, to support the later high-  
519 energy requirements of metamorphosis or to use during the early juvenile stage, when food  
520 availability may be uncertain. In bonefish leptocephali, SFA, MUFA, and PUFA FAs were  
521 used during metamorphosis (*e.g.*, 30% use of 16:0, 12% of 16:1 $\omega$ 7, 7% of 18:5 $\omega$ 3), but most of  
522 22:6 $\omega$ 3 was conserved (Padrón et al. 1996). More species of leptocephali including those that  
523 reach larger sizes than the Serrivomeridae should be examined to further evaluate how FA  
524 compositions changes during growth and metamorphosis.

525

### 526 **Regional differences in leptocephali and POM**

527 The isotopic signatures of leptocephali in the 3 current zones showed variations that  
528 appeared to be related to the POM signatures in each zone. Both  $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$  values of  
529 Nemichthyidae and Muraenidae larvae decreased to some extent from north (SECC) to south  
530 (STCC) and the same pattern was seen in POM signatures, especially for  $\delta^{15}\text{N}$ . The  
531 compositions of the FAs of POM and leptocephali also varied significantly among the current  
532 zones. This suggests there is regional variability in the nutritional quality (SFA and 22:6 $\omega$ 3  
533 contributions) and availability (18:1 $\omega$ 9, 16:1 $\omega$ 7 and 18:4 $\omega$ 3) of POM. For example, the SECC  
534 POM had the highest percentage of SFAs and the lowest percentage of MUFAs and PUFAs,  
535 which indicates a lower nutritional quality. This may be reflected in the FA compositions of  
536 Serrivomeridae larvae that were mostly collected in the SECC, since they also had high SFA  
537 contents and low contents of PUFAs compared to the other more widely distributed families.  
538 In contrast, the SEC and STCC tended to have POM with higher nutritional quality with larger  
539 PUFA and  $\omega$ 3 contributions.

540 These observed differences in POM may have affected the composition of the  
541 leptocephali, because many studies indicate that diversity and bioavailability of POM plays a  
542 key role in ecosystem functioning by supporting the trophic network (Grémare et al. 1997,  
543 Carlier et al. 2007), with regional variability in trophic resources being reflected in the  
544 consumers (Cartes et al. 2014, Chauvelon et al. 2014). Our sampling was spread across 20  
545 degrees of latitude and crossed 3 current systems, so it is not surprising that geographic  
546 variations were observed in both the SI signatures and FA compositions of POM and  
547 leptocephali. This variation was likely due to latitudinal differences in planktonic community  
548 structure in the different current systems and temperature regimes, because differences in the  
549  $\delta^{15}\text{N}$  of primary producers can cause variations in the  $\delta^{15}\text{N}$  values of POM and organisms  
550 between regions (Somes et al. 2010, Cartes et al. 2014, Lorrain et al. 2015, Soares et al. 2015).  
551 Longitudinal differences in the  $\delta^{15}\text{N}$  of mesozooplankton have also been observed around New  
552 Caledonia (Hunt et al. 2015).

553 It is clear though, that questions remain about the feeding ecology of leptocephali,  
554 because this study and the study in the western Indian Ocean (Feunteun et al. 2015) have found  
555 differences in the compositions of other taxa of leptocephali collected from the same area.  
556 Feunteun et al. (2015) found that Nemichthyidae leptocephali had lower  $\delta^{15}\text{N}$  values than  
557 Muraenidae and Serrivomeridae leptocephali (and other families), and similar differences were  
558 seen between Nemichthyidae and Muraenidae larvae in the STCC zone in the present study.  
559 Similar  $\delta^{15}\text{N}$  differences were also seen between *Anguilla japonica* and Congridae larvae of the  
560 genus *Ariosoma* (Miyazaki et al. 2011) in the western North Pacific. Possible reasons  
561 proposed for these differences are similar to those already discussed above, such as different  
562 types of POM being selected, the taxa feeding at different depths where the POM is slightly  
563 different, differences in assimilation of materials from the POM, or physiological differences  
564 among leptocephalus taxa (Miyazaki et al. 2011, Feunteun et al. 2015). To begin to evaluate  
565 these possibilities, more research is needed using SI and FA analyses of leptocephali and other  
566 food web components in a wider range of areas to gain a better understanding of the feeding  
567 ecology of these fish larvae.

568

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577

578

## 579 **LITERATURE CITED**

580 Abi-ayad S, Boutiba Z, Melard C, Kestemont P (2004) Dynamics of total body fatty acids  
581 during early ontogeny of pikeperch (*Sander lucioperca*) larvae. *Fish Physiol Biochem*  
582 30:129–136

583 Abrantes K, Sheaves M, (2009) Food web structure in a near-pristine mangrove area of the  
584 Australian Wet Tropics. *Est Coast Shelf Sci* 82:597–607

585 Alldredge AL, Silver MW (1988) Characteristics, dynamics and significance of marine snow.  
586 *Progr Oceanogr* 20:41–82

587 Bishop RE, Torres JJ, Crabtree RE (2000) Chemical composition and growth indices in  
588 leptocephalus larvae. *Mar Biol* 137:205–214

589 Böhlke EB (ed) (1989) Leptocephali. *Fishes of the Western North Atlantic. Part 9, Vol. 2.*  
590 *Sears Foundation for Marine Research, New Haven.*

591 Boon AR, Duineveld GCA (1996) Phytopigments and fatty acids as molecular markers for the  
592 quality of near-bottom particulate organic matter in the North Sea. *Neth J Sea Res* 35:279–  
593 291

594 Budge SM, Iverson SJ, Koopman HN (2006). Studying trophic ecology in marine ecosystems  
595 using fatty acids: a primer on analysis and interpretation. *Mar Mam Sci* 22:759–801

596 Canuel EA, Cloern JE, Ringelberg DB, Guckert JB, Rau GH (1995) Molecular and isotopic  
597 tracers used to examine sources of organic matter and its incorporation into the food webs  
598 on San Francisco Bay. *Limnol Oceanogr* 40:67–81

599 Carlier A, Riera P, Alouroux JM, Bodiou J-Y, Grémare A (2007) Benthic trophic network in  
600 the Bay of Banyuls-sur-Mer (northwest Mediterranean, France): An assessment based on  
601 stable carbon and nitrogen isotopes analysis. *Est Coast Shelf Sci* 72:1–15

602 Cartes JE, Fanelli E, Kapiris K, Bayhan YK and others (2014) Spatial variability in the trophic  
603 ecology and biology of the deep-sea shrimp *Aristaeomorpha foliacea* in the Mediterranean  
604 Sea. *Deep-Sea Res* 87:1–13

605 Castonguay M, McCleave JD (1987) Vertical distributions, diel and ontogenetic vertical  
606 migrations and net avoidance of leptocephali of *Anguilla* and other common species in the  
607 Sargasso Sea. J Plankton Res 9:195–214.

608 Chouvelon T, Chappuis A, Bustamante P, Lefebvre S and others (2014) Trophic ecology of  
609 European sardine *Sardina pilchardus* and European anchovy *Engraulis encrasicolus* in the  
610 Bay of Biscay (north-east Atlantic) inferred from  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values of fish and  
611 identified mesozooplanktonic organisms. J Sea Res 85:277–291

612 Clarke KR (1993) Non-parametric multivariate analyses of changes in community structure.  
613 Aust J Ecol 18:117–143

614 Clarke KR, Warwick RM (2001) Change in marine communities: An approach to statistical  
615 analysis and interpretation. PRIMER-E Ltd, Plymouth Marine Laboratory, UK.

616 Close HG, Wakeham SG, Pearson A (2014) Lipid and  $^{13}\text{C}$  signatures of submicron and  
617 suspended particulate organic matter in the Eastern Tropical North Pacific: Implications  
618 for the contribution of Bacteria. Deep-Sea Res I 85:15–34

619 Dalsgaard J, St John M, Kattner G, Muller-Navarra D, Hagen W (2003) Fatty acid trophic  
620 markers in the pelagic marine environment. Adv Mar Biol 46:278–340

621 Deibel D, Parrish CC, Grønkjær PP, Munk P, Gissel Nielsen T (2012) Lipid class and fatty  
622 acid content of the leptocephalus larva of tropical eels. Lipids 47:623–634

623 DeNiro MJ, Epstein S (1978) Influence of diet on the distribution of carbon isotopes in  
624 animals. Geochim. Cosmochim Acta 42:495–506

625 DeNiro MJ, Epstein S (1981) Influence of diet on the distribution of nitrogen isotopes in  
626 animals. Geochim. Cosmochim Acta 45:341–351

627 Dewick PM (1997) The Acetate Pathway: Fatty Acids and Polyketides. In: Medicinal Natural  
628 Products: A Biosynthetic Approach. John Wiley & Sons, New York

629 Druffel ERM, Griffin S, Bauer JE, Wolgast DM, Wang X-C (1998) Distribution of particulate  
630 organic carbon and radiocarbon in the water column from the upper slope to the abyssal  
631 NE Pacific Ocean. Deep-Sea Res. II 45:667–687

632 Druffel ERM, Bauer JE, Griffin S, Hwang J (2003) Penetration of anthropogenic carbon into  
633 organic particles of the deep ocean. Geophys Res Lett 30:14

634 Ederington MC, McManus GB, Harvey HR (1995) Trophic transfer of fatty acids, sterols, and  
635 a triterpenoid alcohol between bacteria, a ciliate, and the copepod *Acartia tonsa*. Limnol  
636 Oceanogr 40:860–867

637 Engel A, Harlay J, Piontek J, Chou L (2012) Contribution of combined carbohydrates to  
638 dissolved and particulate organic carbon after the spring bloom in the northern Bay of  
639 Biscay (North-Eastern Atlantic Ocean) Cont Shelf Res 45:42–53

640 Falk-Petersen S, Hagen W, Kattner G, Clark A, Sargent J (2000) Lipids, trophic relationships,  
641 and biodiversity in Arctic and Antarctic krill. Can J Fish Aquat Sci 57:178–191

642 Feunteun E, Miller MJ, Carpentier A, Aoyama J, and others (2015) Stable isotopic composition  
643 of anguilliform leptocephali and other food web components from west of the Mascarene  
644 Plateau. Progr Oceanogr

645 Fry B, Sherr E B (1984)  $\delta^{13}\text{C}$  measurements as indicators of carbon flow in marine and  
646 freshwater ecosystems. Contrib Mar Sci 27:13–47

647 Furuita H, Unuma T, Nomura K, Tanaka H, Okuzawa K, Sugita T, Tamamoto T (2006) Lipid  
648 and fatty acid composition of eggs producing larvae with high survival rate in the Japanese  
649 eel. J Fish Biol 69:1178–1189

650 Ganachaud A, Cravatte S, Melet A, Schiller A and others (2014) The Southwest Pacific Ocean  
651 circulation and climate experiment (SPICE). J Geophys Res Oceans 119:7660–7686

652 Goericke R, Fry B (1994) Variations of marine plankton  $\delta^{13}\text{C}$  with latitude, temperature, and  
653 dissolved  $\text{CO}_2$  in the world Ocean. Global Biogeochem Cycle 8:85–90

654 Govoni JJ (2010) Feeding on protists and particulates by the leptocephali of the worm eels  
655 *Myrophis* spp. (Teleostei: Anguilliformes: Ophichthidae), and the potential energy  
656 contribution of large aloricate protozoa. Sci Mar 74:339–344

657 Grémare A, Amouroux JM, Charles F, Dinét A and others (1997) Temporal changes in the  
658 biochemical composition and nutritional value of the particulate organic matter available  
659 to surface deposit-feeders: a two year study. Mar Ecol Prog Ser 150:195–206

660 Grote B, Hagen W, Lipinski MR, Verheye HM, Stenevik EK, Ekau W (2011) Lipids and fatty  
661 acids as indicators of egg condition, larval feeding and maternal effects in Cape hakes  
662 (*Merluccius paradoxus* and *M. capensis*). Mar Biol 158:1005–1017

663 Hall D, Lee SY, Meziane T (2006) Fatty acids as trophic tracers in an experimental estuarine  
664 food chain: tracer transfer. J Exp Mar Biol Ecol 336:42–53

665 Holloway CF, Cowen JP (1997) Development of a scanning confocal laser microscopic  
666 technique to examine the structure and composition of marine snow. Limnol Oceanogr  
667 42:1340–1352

668 Hunt BPV, Allain V, Menkes C, Lorrain A and others (2015) A coupled stable isotope-size  
669 spectrum approach to understanding pelagic food-web dynamics: A case study from the  
670 southwest sub-tropical Pacific. *Deep-Sea Res II* 113:208–224

671 Hwang J, Montluçon D, Eglinton TI (2009) Molecular and isotopic constraints on the sources  
672 of suspended particulate organic carbon on the northwestern Atlantic margin. *Deep-Sea*  
673 *Res I* 56:1284–1297

674 Jeffrey AWA, Pflaum RC, Brooks JM, Sackett WM (1983) Vertical trends in particulate  
675 organic carbon  $^{13}\text{C}:^{12}\text{C}$  ratios in the upper water column. *Deep-Sea Res* 30:971–983

676 Kaneda (1991) *iso*- and *anteiso*-fatty acids in bacteria: Biosynthesis, function and taxonomic  
677 significance. *Microbiol Rev* 55:288–302

678 Kattner G, Hagen W, Lee RF, Campbell R and others (2007) Perspectives on marine  
679 zooplankton lipids. *Can J Fish Aquat Sci* 64:1628–1639

680 Kiørboe T (2000) Colonization of marine snow aggregates by invertebrate zooplankton:  
681 abundance, scaling, and possible role. *Limnol Oceanogr* 45:479–484

682 Lee RF, Hagen W, Kattner G (2006) Lipid storage in marine zooplankton - a review. *Mar Ecol*  
683 *Prog Ser* 307:273–306

684 Lorrain A, Savoye N, Chauvaud L, Paulet Y-M, Naulet N (2003) Decarbonation and  
685 preservation method for the analysis of organic C and N contents and stable isotope ratios  
686 of low-carbonated suspended particulate material. *Analyt Chim Acta* 491:125–133

687 Lorrain A, Graham BS, Popp BN, Allain V and others (2015) Nitrogen isotopic baselines and  
688 implications for estimating foraging habitat and trophic position of yellowfin tuna in the  
689 Indian and Pacific Oceans. *Deep-Sea Res* 113:188–198

690 Marui M, Arai T, Miller MJ, Jellyman DJ, Tsukamoto K (2001) Comparison of early life  
691 history between New Zealand temperate eels and Pacific tropical eels revealed by otolith  
692 microstructure and microchemistry. *Mar Ecol Progr Ser* 213:273–284

693 Meziane T, Bodineau L, Retière C, Thoumelin G (1997) The use of lipid markers to examine  
694 sources of organic matter and its incorporation into food web of the intertidal salt marsh-  
695 flat ecosystem, Mont Saint Michel Bay, France. *J Sea Res* 38:47–58

696 Meziane T, Tsuchiya M (2000) Fatty acids as tracers of organic matter in the sediment and web  
697 of a mangrove/intertidal flat ecosystem, Okinawa, Japan. *Mar Ecol Progr Ser* 200:49–57

698 Meziane T, Sanabe MC, Tsuchiya M (2002) Role of fiddler crabs of a subtropical intertidal flat  
699 on the fate of sedimentary fatty acids. *Exp Mar Biol Ecol* 270:191–201

700 Meziane T, Lee SY, Mfilinge PL, Shin PKS, Lam MHW, Tsuchiya M (2007) Inter-specific  
701 and geographical variations in the fatty acid composition of mangrove leaves: implications  
702 for using fatty acids as a taxonomic tool and tracers of organic matter. *Mar Biol* 150:1103–  
703 1113

704 Miller MJ (2009) Ecology of anguilliform leptocephali: Remarkable transparent fish larvae of  
705 the ocean surface layer. *Aqua-BioSci Monogr* 2(4):1–94

706 Miller MJ, K Tsukamoto (2004) An introduction to leptocephali: biology and identification.  
707 Tokyo: Ocean Research Institute, University of Tokyo, 96 pp

708 Miller MJ, Aoyama J, Mochioka N, Otake T and others (2006) Geographic variation in the  
709 assemblages of leptocephali in the western South Pacific. *Deep-Sea Res I* 53:776–794

710 Miller MJ, Otake T, Aoyama J, Wouthuyzen S, Suharti S, Sugeha HY, Tsukamoto K (2011)  
711 Observations of gut contents of leptocephali in the North Equatorial Current and Tomini  
712 Bay, Indonesia. *Coast Mar Sci* 35:277–288

713 Miller MJ, Chikaraishi Y, Ogawa NO, Yamada Y, Tsukamoto K, Ohkouchi N (2013) A low  
714 trophic position of Japanese eel larvae indicates feeding on marine snow. *Biol Lett* 9:  
715 20120826

716 Minagawa M, Wada E (1984) Stepwise enrichment of  $\delta^{15}\text{N}$  along food chains: Further  
717 evidence and the relation between  $\delta^{15}\text{N}$  and animal age. *Geochim Cosmochim Acta*  
718 48:1135–1140

719 Miyazaki S, Kim H-Y, Zenimoto K, Kitagawa T, Miller MJ, Kimura S (2011) Stable isotope  
720 analysis of two species of anguilliform leptocephali (*Anguilla japonica* and *Ariosoma*  
721 *major*) relative to their feeding depth in the North Equatorial Current region. *Mar Biol*  
722 158:2555–2564

723 Mochioka N, Iwamizu M (1996) Diet of anguillid larvae: leptocephali feed selectively on  
724 larvacean houses and fecal pellets. *Mar Biol* 125:447–452

725 Mortillaro JM, Pouilly M, Wach M, Freitas CEC, Abril G, Meziane T (2015) Trophic  
726 opportunism of central Amazon floodplain fish. *Freshw Biol*, Early view.  
727 doi: 10.1111/fwb.12598

728 Mortillaro JM, Abril G, Moreira-Turcq P, Sobrinho RL, Perez M, Meziane T (2011) Fatty acid  
729 and stable isotope ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ ) signatures of particulate organic matter in the lower  
730 Amazon River: Seasonal contrasts and connectivity between floodplain lakes and the  
731 mainstem. *Organic Geochemistry* 42:1159–1168



732 Najdek M, Debobbis D, Mioković D, Ivančić I (2002) Fatty acid and phytoplankton  
733 compositions of different types of mucilaginous aggregates in the northern Adriatic. J  
734 Plankt Res 24:424–441

735 Otake T, Nogami K, Maruyama K (1993) Dissolved and particulate organic matter as possible  
736 food sources for eel leptocephali. Mar Ecol Prog Ser 92:27–34

737 Oksanen J, Blanchet GF, Kindt R, Legendre P, Minchin PR, O'Hara RB, Simpson GL,  
738 Solymos P, Henry M, Stevens H, Wagner H (2014) Package 'vegan': Community Ecology  
739 Package. Package version 2.2-0

740 Padrón D, Lindley VA, Pfeiler E (1996) Changes in lipid composition during metamorphosis  
741 of bonefish (*Albula* sp.) leptocephali. Lipids 31:513–519

742 Passow U (2002) Transparent exopolymer particles (TEP) in aquatic environments. Progr  
743 Oceanogr 55:287–333

744 Peterson BJ, Fry B (1987) Stable isotopes in ecosystem studies. Ann Rev Ecol Syst 18:293–  
745 320

746 Pfeiler E (1999) Developmental physiology of elopomorph leptocephali. Comp Biochem  
747 Physiol A123:113–128

748 Pfeiler E, Toyoda H, Williams MD, Nieman RA (2002) Identification, structural analysis and  
749 function of hyaluronan in developing fish larvae (leptocephali). Comp Biochem Physiol B  
750 132:443–451

751 Pitt KA, Connolly M, Meziane T (2009) Stable isotope and fatty acid tracers in energy and  
752 nutrient studies of jellyfish: a review. Hydrobiologia 616:119–132

753 Plante S, Pernet F, Haché R, Ritchie R, Ji B, McIntosh D (2006) Ontogenetic variations in lipid  
754 class and fatty acid composition of haddock larvae *Melanogrammus aeglefinus* in relation  
755 to changes in diet and microbial environment. Aquaculture 263:107–121

756 Popp BN, Laws EA, Bidigare RR, Dore JE, Hanson KL, Wakeham SG (1998) Effect of  
757 phytoplankton cell geometry on carbon isotopic fractionation. Geochim Cosmochim Acta  
758 62:69–77

759 Qiu B, Chen S (2004) Seasonal modulations in the eddy field of the South Pacific Ocean. J  
760 Phys Oceanogr 34:1515–1527

761 Rainuzzo J, Reitan K, Olsen Y (1997) The significance of lipids at early stages of marine fish:  
762 a review. Aquaculture 155:103–115

763 Rau GH, Mearns AJ, Young DR, Olson RJ, Schafer HA, Kaplan IR (1983) Animal  $^{13}\text{C}/^{12}\text{C}$   
764 correlates with trophic level in pelagic food webs. Ecology 64:1314–1318

765 Riemann L, Alfredsson H, Hansen MM, Als TD and others (2010) Qualitative assessment of  
766 the diet of European eel larvae in the Sargasso Sea resolved by DNA barcoding. *Biol Lett*  
767 6:819–822

768 Sargent JR, Bell JG, Bell MV, Henderson RJ, Tocher DR (1993) The metabolism of  
769 phospholipids and polyunsaturated fatty acids in fish. In: Lahlou B and Vitiello P (eds)  
770 Aquaculture: Fundamental and applied research. American Geophysical Union,  
771 Washington, DC, p 103–124

772 Sargent JR (1995). Origin and functions of egg lipids: nutritional implications. In: Bromage,  
773 NR, Roberts, RJ (eds), Brood stock Management and Egg and Larval Quality. Blackwell  
774 Science, London, pp 353–372

775 Skoog A, Alldredge A, Passow U, Dunne J, Murray J (2008) Neutral aldoses as source  
776 indicators for marine snow. *Mar Chem* 108:195–206

777 Scott CL., Kwasniewski S, Falk-Petersen S, Sargent JR (2002) Species differences, origins and  
778 functions of fatty alcohols and fatty acids in the wax esters and phospholipids of *Calanus*  
779 *hyperboreus*, *C. glacialis* and *C. finmarchicus* from Arctic waters. *Mar Ecol Prog Ser*  
780 235:127–134

781 Schomburg G (1987) Gaschromatographie, second ed. VCH, Weinheim, p 62–72

782 Shanks AL, Walters K (1997) Holoplankton, meroplankton, and meiofauna associated with  
783 marine snow. *Mar Ecol Prog Ser* 156:75–86

784 Skerratt JH, Nichols PD, McMeekin TA, Burton H (1995) Seasonal and inter-annual changes  
785 in planktonic biomass and community structure in eastern Antarctica using signature  
786 lipids. *Mar Chem* 51:93–113

787 Somes CJ, Schmittner A, Galbraith ED, Lehmann MF and others (2010) Simulating the global  
788 distribution of nitrogen isotopes in the ocean. *Global Biogeochem Cycles* 24:GB4019

789 Soares MA, Bhaskar PV, Naik RK, Dessai D, George J, Tiwari M, Anilkumar N (2015)  
790 Latitudinal  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  variations in particulate organic matter (POM) in surface  
791 waters from the Indian ocean sector of Southern Ocean and the Tropical Indian Ocean in  
792 2012. *Deep-Sea Res II* 11:186–196

793 Styrrishave B, Andersen O (2000) Seasonal variations in hepatopancreas fatty acid profiles of  
794 two colour forms of shore crabs, *Carcinus maenas*. *Mar Biol* 137:415–422

795 Tanaka H, Kagawa H, Ohta H, Okuzawa K, Hirose K (1995) The first report of eel larvae  
796 ingesting rotifers. *Fish Sci* 61:171–172

- 797 Waite AM, Muhling BA, Holl CM, Beckley LE and others (2007) Food web structure in two  
798 counter-rotating eddies based on  $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$  isotopic analyses. *Deep-Sea Res II*  
799 54:1055–1075
- 800 Wiegand MD (1996) Composition, accumulation and utilization of yolk lipids in teleost fish.  
801 *Rev Fish Biol Fish* 6:259–286  
802

803  
804

**Table 1.** Fatty acid relative contribution (%) and Carbon ( $\delta^{13}\text{C}$ ) and Nitrogen ( $\delta^{15}\text{N}$ ) mean isotopic signature of Particulate Organic Matter (POM) for 13 stations (3 replicates per station) and all leptocephali tissues for the three families Muraenidae (MR), Nemichthyidae (NM) and Serrivomeridae (SR). All values are mean  $\pm$  S.D. n is the number of samples.

Isotopes/ FA	POM (n=39)	MR (n=27)	NM (n=28)	SR (n=41)	POM (stn=13)	MR (n=27)	NM (n=28)	SR (n=41)	
<b>Stable Isotopes</b>				<b>Polyunsat.</b>					
$\delta^{15}\text{N}$	6.1 $\pm$ 2.3	6.7 $\pm$ 2.7	4.7 $\pm$ 3.3	10.9 $\pm$ 1.9	16:2 $\omega$ 4	1.7 $\pm$ 0.41	0.57 $\pm$ 0.19	0.61 $\pm$ 0.17	0.72 $\pm$ 0.33
$\delta^{13}\text{C}$	-26.6 $\pm$ 0.7	-20.5 $\pm$ 1.1	-19.9 $\pm$ 0.8	-21.0 $\pm$ 0.8	16:2 $\omega$ 6	- $\pm$ -	0.05 $\pm$ 0.02	0.09 $\pm$ 0.02	0.04 $\pm$ 0.02
<b>Saturated</b>									
12:0	0.51 $\pm$ 0.25	0.08 $\pm$ 0.12	0.04 $\pm$ 0.06	0.07 $\pm$ 0.1	16:4 $\omega$ 3	0.22 $\pm$ 0.06	0.05 $\pm$ 0.05	0.02 $\pm$ 0.03	0.05 $\pm$ 0.04
13:0	0.11 $\pm$ 0.03	0.02 $\pm$ 0.02	0.02 $\pm$ 0.01	0.03 $\pm$ 0.1	18:2 $\omega$ 6	1.21 $\pm$ 0.26	2.76 $\pm$ 0.47	2.97 $\pm$ 0.44	2.55 $\pm$ 0.6
14:0	14.05 $\pm$ 1.71	3.99 $\pm$ 1.32	4.63 $\pm$ 0.86	4.12 $\pm$ 0.6	18:3 $\omega$ 3	0.45 $\pm$ 0.09	1.15 $\pm$ 0.33	1.17 $\pm$ 0.56	0.8 $\pm$ 0.28
15:0	1.7 $\pm$ 0.22	1.52 $\pm$ 0.23	1.71 $\pm$ 0.37	2.1 $\pm$ 0.2	18:3 $\omega$ 6	0.42 $\pm$ 0.08	0.28 $\pm$ 0.06	0.23 $\pm$ 0.06	0.39 $\pm$ 0.1
16:0	35.91 $\pm$ 2.28	20.94 $\pm$ 2.44	24.04 $\pm$ 2.64	26.63 $\pm$ 4.3	18:4 $\omega$ 3	1.69 $\pm$ 0.52	1.24 $\pm$ 0.26	1.37 $\pm$ 0.44	1.16 $\pm$ 0.37
17:0	0.67 $\pm$ 0.11	1.73 $\pm$ 0.18	1.26 $\pm$ 0.18	1.75 $\pm$ 0.3	20:2 $\omega$ 6	- $\pm$ -	0.24 $\pm$ 0.1	0.11 $\pm$ 0.05	0.08 $\pm$ 0.05
18:0	19.47 $\pm$ 2.31	9.32 $\pm$ 1.25	5.14 $\pm$ 1.7	9.1 $\pm$ 2.9	20:3	- $\pm$ -	0.15 $\pm$ 0.04	0.15 $\pm$ 0.04	0.09 $\pm$ 0.03
19:0	0.46 $\pm$ 0.09	0.31 $\pm$ 0.1	0.2 $\pm$ 0.09	0.34 $\pm$ 0.2	20:3 $\omega$ 6	- $\pm$ -	0.37 $\pm$ 0.08	0.24 $\pm$ 0.06	0.27 $\pm$ 0.1
20:0	0.85 $\pm$ 0.1	0.27 $\pm$ 0.07	0.14 $\pm$ 0.03	0.35 $\pm$ 0.2	20:4 $\omega$ 3	0.09 $\pm$ 0.02	1.4 $\pm$ 0.77	0.86 $\pm$ 0.3	0.96 $\pm$ 0.69
21:0	0.06 $\pm$ 0.02	0.04 $\pm$ 0.01	0.03 $\pm$ 0.05	0.03 $\pm$ 0	20:4 $\omega$ 6	0.13 $\pm$ 0.04	2.82 $\pm$ 0.79	2.81 $\pm$ 0.51	3.49 $\pm$ 0.96
22:0	0.58 $\pm$ 0.13	0.19 $\pm$ 0.04	0.14 $\pm$ 0.03	0.17 $\pm$ 0.1	20:5 $\omega$ 3	1.02 $\pm$ 0.22	7.85 $\pm$ 0.97	8.52 $\pm$ 1.22	5.05 $\pm$ 2.07
24:0	0.58 $\pm$ 0.25	0.08 $\pm$ 0.06	0.04 $\pm$ 0.03	0.09 $\pm$ 0.1	22:2 $\omega$ 6	0.27 $\pm$ 0.14	- $\pm$ -	- $\pm$ -	- $\pm$ -
<b><math>\Sigma</math> SFA (%)</b>	<b>75.23 <math>\pm</math> 4.58</b>	<b>38.5 <math>\pm</math> 3.65</b>	<b>37.41 <math>\pm</math> 4.2</b>	<b>44.79 <math>\pm</math> 7.5</b>	22:4 $\omega$ 6	- $\pm$ -	0.36 $\pm$ 0.15	0.27 $\pm$ 0.21	0.12 $\pm$ 0.13
<b>Monounsatur.</b>									
16:1 $\omega$ 5	0.07 $\pm$ 0.03	0.14 $\pm$ 0.03	0.15 $\pm$ 0.03	0.13 $\pm$ 0	22:5 $\omega$ 3	- $\pm$ -	2.79 $\pm$ 1.58	0.95 $\pm$ 0.51	0.93 $\pm$ 0.59
16:1 $\omega$ 7	4.42 $\pm$ 0.88	5.71 $\pm$ 1.14	7.6 $\pm$ 1.77	6.59 $\pm$ 1.3	22:5 $\omega$ 6	0.19 $\pm$ 0.11	2.18 $\pm$ 0.65	2.24 $\pm$ 0.37	2.34 $\pm$ 0.63
16:1 $\omega$ 9	2.07 $\pm$ 0.5	0.54 $\pm$ 0.09	0.66 $\pm$ 0.13	0.63 $\pm$ 0.1	22:6 $\omega$ 3	1.67 $\pm$ 0.79	18.1 $\pm$ 2.13	16.8 $\pm$ 2.58	14.8 $\pm$ 3.16
17:1 $\omega$ 7	0.37 $\pm$ 0.08	0.45 $\pm$ 0.12	0.49 $\pm$ 0.11	0.32 $\pm$ 0.1	<b><math>\Sigma</math> PUFA (%)</b>	<b>9.1 <math>\pm</math> 2.1</b>	<b>42 <math>\pm</math> 3.7</b>	<b>39 <math>\pm</math> 4.2</b>	<b>34 <math>\pm</math> 5.7</b>
17:1 $\omega$ 9	- $\pm$ -	0.45 $\pm$ 0.1	0.73 $\pm$ 0.15	0.75 $\pm$ 0.1	<b>Branched-chain</b>				
18:1 $\omega$ 5	- $\pm$ -	0.1 $\pm$ 0.03	0.1 $\pm$ 0.03	0.11 $\pm$ 0	14:0iso	0.35 $\pm$ 0.1	0.01 $\pm$ 0.01	0.22 $\pm$ 0.01	0.03 $\pm$ 0.01
18:1 $\omega$ 7	0.71 $\pm$ 0.16	4.18 $\pm$ 0.77	3.93 $\pm$ 0.63	2.82 $\pm$ 0.7	15:0anteiso	0.45 $\pm$ 0.06	0.03 $\pm$ 0.01	0.04 $\pm$ 0.02	0.05 $\pm$ 0.03
18:1 $\omega$ 9	5.3 $\pm$ 1.06	5.84 $\pm$ 0.94	8.33 $\pm$ 1.72	8.77 $\pm$ 1.3	15:0iso	0.37 $\pm$ 0.05	0.12 $\pm$ 0.03	0.14 $\pm$ 0.03	0.17 $\pm$ 0.05
19:1 $\omega$ 9	- $\pm$ -	0.03 $\pm$ 0.02	0.02 $\pm$ 0.02	0.03 $\pm$ 0	16:0iso	0.22 $\pm$ 0.04	0.08 $\pm$ 0.02	0.1 $\pm$ 0.04	0.13 $\pm$ 0.04
20:1 $\omega$ 7	- $\pm$ -	0.18 $\pm$ 0.08	0.12 $\pm$ 0.04	0.09 $\pm$ 0.1	17:0anteiso	0.68 $\pm$ 0.17	0.08 $\pm$ 0.02	0.1 $\pm$ 0.03	0.11 $\pm$ 0.04
20:1 $\omega$ 9	- $\pm$ -	0.22 $\pm$ 0.21	0.13 $\pm$ 0.07	0.1 $\pm$ 0.1	17:0iso	0.05 $\pm$ 0.01	0.12 $\pm$ 0.03	0.26 $\pm$ 0.05	0.27 $\pm$ 0.06
22:1 $\omega$ 11	0.38 $\pm$ 0.13	0.09 $\pm$ 0.1	0.03 $\pm$ 0.02	0.06 $\pm$ 0	18:0iso	0.26 $\pm$ 0.09	0.07 $\pm$ 0.05	0.16 $\pm$ 0.06	0.13 $\pm$ 0.05
22:1 $\omega$ 9	- $\pm$ -	0.05 $\pm$ 0.02	0.01 $\pm$ 0.01	0.02 $\pm$ 0	<b><math>\Sigma</math> BrFA (%)</b>	<b>2.38 <math>\pm</math> 0.3</b>	<b>0.5 <math>\pm</math> 0.1</b>	<b>0.8 <math>\pm</math> 0.1</b>	<b>0.9 <math>\pm</math> 0.2</b>
24:1 $\omega$ 9	- $\pm$ -	0.08 $\pm$ 0.05	0.06 $\pm$ 0.05	0.07 $\pm$ 0.1	Total FA (mg.g-1)	3.6 $\pm$ 0.97	11.7 $\pm$ 7.44	5.22 $\pm$ 2.51	5.41 $\pm$ 3.99
<b><math>\Sigma</math> MUFA (%)</b>	<b>13.33 <math>\pm</math> 2.66</b>	<b>18.69 <math>\pm</math> 1.15</b>	<b>22.38 <math>\pm</math> 2.9</b>	<b>20.49 <math>\pm</math> 2.5</b>	$\Sigma$ $\omega$ 3	5.14 $\pm$ 1.46	32.5 $\pm$ 3.77	29.7 $\pm$ 3.84	23.7 $\pm$ 5.51
				$\Sigma$ $\omega$ 6					
				$\Sigma$ EFA					
				2.82 $\pm$ 0.35					
				28.7 $\pm$ 1.3					
				28.1 $\pm$ 1.44					
				23.3 $\pm$ 2.06					

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**Table 2.** Fatty acid relative contribution (%) and Carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) mean isotopic signature of Serrivomeridae leptocephali from four different size groups ( $\leq 10$ , 10.1-20.0, 20.1-40.0 and 40.1-60.0 mm). The 5 samples of  $\leq 10$  mm larvae each include 2 larvae pooled together. All values are mean  $\pm$  S.D. n is the number of samples.

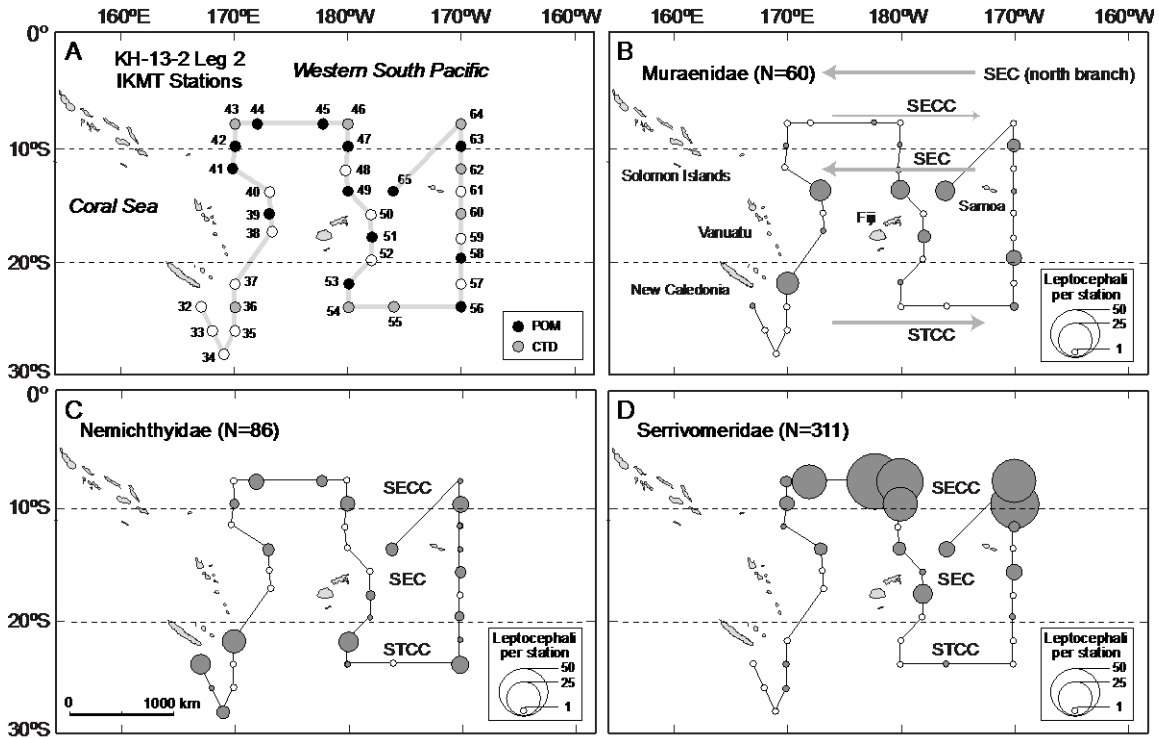
Isotopes/ FA	$\leq 10$ mm (n=5)	10-20 mm (n=6)	20-40 mm (n=20)	40-60 mm (n=10)	$\leq 10$ mm (n=5)	10-20 mm (n=6)	20-40 mm (n=20)	40-60 mm (n=10)	
<b>Stable Isotopes</b>									
$\delta^{15}\text{N}$	11.1 $\pm$ 1.4	11.8 $\pm$ 0.8	10.6 $\pm$ 1.9	10.0 $\pm$ 2.3					
$\delta^{13}\text{C}$	-19.9 $\pm$ 0.57	-21.3 $\pm$ 1.0	-20.6 $\pm$ 0.8	-21.4 $\pm$ 0.5					
<b>Saturated</b>									
12:0	0.13 $\pm$ 0.11	0.06 $\pm$ 0.06	0.07 $\pm$ 0.05	0.04 $\pm$ 0.02					
13:0	0.05 $\pm$ 0.02	0.04 $\pm$ 0.03	0.03 $\pm$ 0.01	0.03 $\pm$ 0.01					
14:0	4.5 $\pm$ 0.54	3.84 $\pm$ 0.88	3.99 $\pm$ 0.55	4.35 $\pm$ 0.61					
15:0	2.25 $\pm$ 0.29	2.07 $\pm$ 0.27	2.16 $\pm$ 0.16	1.95 $\pm$ 0.12					
16:0	33.23 $\pm$ 5.29	27.01 $\pm$ 1.33	27.22 $\pm$ 2.67	21.95 $\pm$ 1.67					
17:0	1.79 $\pm$ 0.14	1.76 $\pm$ 0.24	1.83 $\pm$ 0.27	1.56 $\pm$ 0.21					
18:0	13.18 $\pm$ 3.9	9.9 $\pm$ 2.25	9.17 $\pm$ 2.13	6.42 $\pm$ 0.62					
19:0	0.69 $\pm$ 0.24	0.32 $\pm$ 0.14	0.3 $\pm$ 0.09	0.24 $\pm$ 0.08					
20:0	0.46 $\pm$ 0.15	0.48 $\pm$ 0.39	0.31 $\pm$ 0.07	0.32 $\pm$ 0.09					
21:0	0.04 $\pm$ 0.02	0.03 $\pm$ 0.01	0.04 $\pm$ 0.01	0.03 $\pm$ 0.01					
22:0	0.24 $\pm$ 0.07	0.16 $\pm$ 0.03	0.17 $\pm$ 0.03	0.14 $\pm$ 0.03					
24:0	0.18 $\pm$ 0.08	0.13 $\pm$ 0.11	0.07 $\pm$ 0.06	0.08 $\pm$ 0.07					
<b><math>\Sigma</math> SFA (%)</b>	<b>56.73 <math>\pm</math> 0.91</b>	<b>45.79 <math>\pm</math> 0.48</b>	<b>45.36 <math>\pm</math> 0.51</b>	<b>37.09 <math>\pm</math> 0.3</b>					
<b>Monounsatur.</b>									
16:1 $\omega$ 5	0.08 $\pm$ 0.04	0.13 $\pm$ 0.02	0.14 $\pm$ 0.03	0.13 $\pm$ 0.02					
16:1 $\omega$ 7	4.95 $\pm$ 0.81	6.54 $\pm$ 1.14	6.31 $\pm$ 0.68	8.01 $\pm$ 1.24					
16:1 $\omega$ 9	0.49 $\pm$ 0.14	0.63 $\pm$ 0.05	0.65 $\pm$ 0.08	0.67 $\pm$ 0.06					
17:1 $\omega$ 7	0.3 $\pm$ 0.03	0.27 $\pm$ 0.07	0.34 $\pm$ 0.1	0.33 $\pm$ 0.08					
17:1 $\omega$ 9	0.6 $\pm$ 0.15	0.77 $\pm$ 0.08	0.73 $\pm$ 0.11	0.84 $\pm$ 0.09					
18:1 $\omega$ 5	0.05 $\pm$ 0.03	0.11 $\pm$ 0.01	0.11 $\pm$ 0.03	0.13 $\pm$ 0.02					
18:1 $\omega$ 7	2.4 $\pm$ 0.3	2.77 $\pm$ 0.32	2.63 $\pm$ 0.78	3.47 $\pm$ 0.38					
18:1 $\omega$ 9	7.81 $\pm$ 2.11	9.33 $\pm$ 0.64	8.76 $\pm$ 1.23	8.92 $\pm$ 0.94					
19:1 $\omega$ 9	0.02 $\pm$ 0.02	0.03 $\pm$ 0.03	0.01 $\pm$ 0.02	0.06 $\pm$ 0.04					
20:1 $\omega$ 7	0.06 $\pm$ 0.02	0.06 $\pm$ 0.03	0.07 $\pm$ 0.02	0.15 $\pm$ 0.07					
20:1 $\omega$ 9	0.07 $\pm$ 0.03	0.07 $\pm$ 0.04	0.08 $\pm$ 0.03	0.19 $\pm$ 0.12					
22:1 $\omega$ 11	0.08 $\pm$ 0.05	0.06 $\pm$ 0.03	0.06 $\pm$ 0.03	0.05 $\pm$ 0.02					
22:1 $\omega$ 9	0.02 $\pm$ 0.01	0.02 $\pm$ 0.01	0.02 $\pm$ 0.02	0.02 $\pm$ 0.01					
24:1 $\omega$ 9	0.1 $\pm$ 0.03	0.05 $\pm$ 0.04	0.07 $\pm$ 0.05	0.07 $\pm$ 0.07					
<b><math>\Sigma</math> MUFA (%)</b>	<b>17.03 <math>\pm</math> 0.27</b>	<b>20.84 <math>\pm</math> 0.18</b>	<b>19.98 <math>\pm</math> 0.23</b>	<b>23.02 <math>\pm</math> 0.23</b>					
<b>Polyunsat.</b>									
16:2 $\omega$ 4	0.36 $\pm$ 0.21	0.83 $\pm$ 0.39	0.68 $\pm$ 0.3	0.94 $\pm$ 0.24					
16:2 $\omega$ 6	0.01 $\pm$ 0.01	0.04 $\pm$ 0.02	0.04 $\pm$ 0.02	0.05 $\pm$ 0.03					
16:4 $\omega$ 3	0.05 $\pm$ 0.05	0.07 $\pm$ 0.04	0.05 $\pm$ 0.04	0.03 $\pm$ 0.02					
18:2 $\omega$ 6	1.93 $\pm$ 0.73	2.81 $\pm$ 0.3	2.78 $\pm$ 0.26	2.25 $\pm$ 0.82					
18:3 $\omega$ 3	0.48 $\pm$ 0.3	0.76 $\pm$ 0.2	0.79 $\pm$ 0.26	1.1 $\pm$ 0.2					
18:3 $\omega$ 6	0.32 $\pm$ 0.05	0.43 $\pm$ 0.06	0.42 $\pm$ 0.1	0.37 $\pm$ 0.14					
18:4 $\omega$ 3	0.69 $\pm$ 0.41	1.17 $\pm$ 0.29	1.23 $\pm$ 0.32	1.24 $\pm$ 0.34					
20:2 $\omega$ 6	0.1 $\pm$ 0.12	0.06 $\pm$ 0.02	0.07 $\pm$ 0.02	0.12 $\pm$ 0.03					
20:3	0.07 $\pm$ 0.04	0.07 $\pm$ 0.02	0.09 $\pm$ 0.02	0.12 $\pm$ 0.02					
20:3 $\omega$ 6	0.16 $\pm$ 0.05	0.25 $\pm$ 0.05	0.25 $\pm$ 0.06	0.4 $\pm$ 0.08					
20:4 $\omega$ 3	0.41 $\pm$ 0.24	0.69 $\pm$ 0.22	0.67 $\pm$ 0.16	1.96 $\pm$ 0.7					
20:4 $\omega$ 6	3.73 $\pm$ 1.25	3.69 $\pm$ 0.77	3.89 $\pm$ 0.66	2.46 $\pm$ 0.74					
20:5 $\omega$ 3	4.04 $\pm$ 1.55	5.02 $\pm$ 0.69	4.47 $\pm$ 2.42	6.75 $\pm$ 0.98					
22:4 $\omega$ 6	0.03 $\pm$ 0.06	0.11 $\pm$ 0.11	0.09 $\pm$ 0.12	0.22 $\pm$ 0.13					
22:5 $\omega$ 3	0.44 $\pm$ 0.17	0.66 $\pm$ 0.1	0.77 $\pm$ 0.19	1.67 $\pm$ 0.77					
22:5 $\omega$ 6	2.12 $\pm$ 0.68	2.36 $\pm$ 0.4	2.51 $\pm$ 0.75	2.08 $\pm$ 0.3					
22:6 $\omega$ 3	10.25 $\pm$ 4.35	13.54 $\pm$ 1.81	14.99 $\pm$ 2.22	17.36 $\pm$ 1.95					
<b><math>\Sigma</math> PUFA</b>	<b>25.17 <math>\pm</math> 0.6</b>	<b>32.55 <math>\pm</math> 0.32</b>	<b>33.78 <math>\pm</math> 0.47</b>	<b>39.01 <math>\pm</math> 0.44</b>					
<b>Branched-chain</b>									
14:0iso	0.04 $\pm$ 0.01	0.02 $\pm$ 0.01	0.03 $\pm$ 0.01	0.02 $\pm$ 0.01					
15:0anteiso	0.11 $\pm$ 0.02	0.05 $\pm$ 0.02	0.05 $\pm$ 0.02	0.03 $\pm$ 0.01					
15:0iso	0.21 $\pm$ 0.07	0.15 $\pm$ 0.02	0.17 $\pm$ 0.04	0.18 $\pm$ 0.04					
16:0iso	0.17 $\pm$ 0.07	0.12 $\pm$ 0.02	0.13 $\pm$ 0.04	0.14 $\pm$ 0.03					
17:0anteiso	0.15 $\pm$ 0.09	0.11 $\pm$ 0.03	0.1 $\pm$ 0.02	0.08 $\pm$ 0.02					
17:0iso	0.27 $\pm$ 0.05	0.25 $\pm$ 0.04	0.27 $\pm$ 0.07	0.29 $\pm$ 0.05					
18:0iso	0.13 $\pm$ 0.05	0.12 $\pm$ 0.09	0.13 $\pm$ 0.05	0.14 $\pm$ 0.03					
<b><math>\Sigma</math> BrFA (%)</b>	<b>1.07 <math>\pm</math> 0.05</b>	<b>0.82 <math>\pm</math> 0.03</b>	<b>0.88 <math>\pm</math> 0.04</b>	<b>0.88 <math>\pm</math> 0.03</b>					
Total FA (mg.g-1)	5.82 $\pm$ 1.08	5.19 $\pm$ 1.92	4.62 $\pm$ 1.41	4.36 $\pm$ 1.54					
$\Sigma \omega$ 3	16.36 $\pm$ 1.01	21.9 $\pm$ 0.48	22.97 $\pm$ 0.8	30.01 $\pm$ 0.71					
$\Sigma \omega$ 6	8.39 $\pm$ 0.37	9.74 $\pm$ 0.22	10.05 $\pm$ 0.25	7.95 $\pm$ 0.28					
$\Sigma$ EFA	18.02 $\pm$ 2.38	22.25 $\pm$ 1.09	23.35 $\pm$ 1.77	26.57 $\pm$ 1.20					

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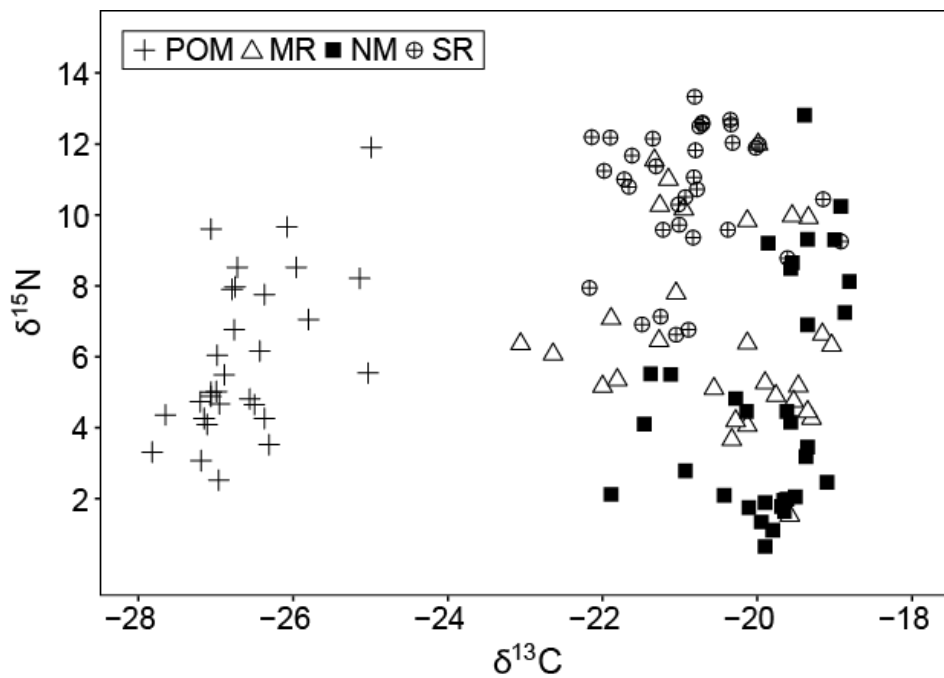
809 **Table 3:** Fatty acid relative contribution (%) of particulate organic matter (POM) from three different currents (South Equatorial Countercurrent (SECC),  
810 South Equatorial Current (SEC) and Sub-Tropical Countercurrent (STCC). All values are mean  $\pm$  S.D. n is the number of samples.  
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Isotopes/ FA	POM in SECC (n=15)	POM in SEC (n=15)	POM in STCC (n=9)	POM in SECC (n=15)	POM in SEC (n=15)	POM in STCC (n=9)	
<b>Stable Isotopes</b>			<b>Polyunsat.</b>				
$\delta^{15}\text{N}$	7.7 $\pm$ 2.3	6.1 $\pm$ 2.2	4.1 $\pm$ 1.0	16:2 $\omega$ 4	0.97 $\pm$ 0.32	1.98 $\pm$ 0.4	2.45 $\pm$ 0.56
$\delta^{13}\text{C}$	-26.2 $\pm$ 0.9	-26.6 $\pm$ 0.5	-27.0 $\pm$ 0.2	16:4 $\omega$ 3	0.26 $\pm$ 0.08	0.22 $\pm$ 0.04	0.18 $\pm$ 0.07
<b>Saturated FA</b>			18:2 $\omega$ 6	1.1 $\pm$ 0.21	1.24 $\pm$ 0.21	1.34 $\pm$ 0.45	
12:0	0.48 $\pm$ 0.19	0.6 $\pm$ 0.32	0.41 $\pm$ 0.23	18:3 $\omega$ 3	0.44 $\pm$ 0.07	0.44 $\pm$ 0.08	0.49 $\pm$ 0.14
13:0	0.1 $\pm$ 0.03	0.13 $\pm$ 0.03	0.07 $\pm$ 0.01	18:3 $\omega$ 6	0.4 $\pm$ 0.09	0.43 $\pm$ 0.07	0.42 $\pm$ 0.06
14:0	14.05 $\pm$ 1.48	14.6 $\pm$ 1.74	13.14 $\pm$ 2.03	18:4 $\omega$ 3	1.16 $\pm$ 0.24	1.93 $\pm$ 0.55	2.16 $\pm$ 0.92
15:0	1.71 $\pm$ 0.25	1.64 $\pm$ 0.25	1.8 $\pm$ 0.11	20:4 $\omega$ 3	0.09 $\pm$ 0.03	0.08 $\pm$ 0.01	0.1 $\pm$ 0.03
16:0	37.75 $\pm$ 1.9	34.87 $\pm$ 2.43	34.59 $\pm$ 2.63	20:4 $\omega$ 6	0.11 $\pm$ 0.03	0.14 $\pm$ 0.05	0.16 $\pm$ 0.04
17:0	0.74 $\pm$ 0.11	0.64 $\pm$ 0.13	0.61 $\pm$ 0.06	20:5 $\omega$ 3	0.88 $\pm$ 0.21	0.9 $\pm$ 0.18	1.43 $\pm$ 0.3
18:0	21.31 $\pm$ 2.2	18.29 $\pm$ 2.56	19.53 $\pm$ 2.08	22:2 $\omega$ 6	0.31 $\pm$ 0.2	0.32 $\pm$ 0.13	0.13 $\pm$ 0.05
19:0	0.45 $\pm$ 0.08	0.42 $\pm$ 0.08	0.54 $\pm$ 0.12	22:5 $\omega$ 6	0.21 $\pm$ 0.15	0.15 $\pm$ 0.08	0.21 $\pm$ 0.11
20:0	0.94 $\pm$ 0.13	0.79 $\pm$ 0.08	0.79 $\pm$ 0.08	22:6 $\omega$ 3	1.17 $\pm$ 0.51	1.71 $\pm$ 0.76	2.43 $\pm$ 1.31
21:0	0.06 $\pm$ 0.02	0.07 $\pm$ 0.02	0.05 $\pm$ 0.02	<b><math>\Sigma</math> PUFA (%)</b>	<b>7.11 <math>\pm</math> 1.44</b>	<b>9.53 <math>\pm</math> 1.96</b>	<b>11.5 <math>\pm</math> 3.47</b>
22:0	0.62 $\pm$ 0.17	0.56 $\pm$ 0.11	0.55 $\pm$ 0.11	<b>Branched-chain</b>			
24:0	0.6 $\pm$ 0.26	0.56 $\pm$ 0.2	0.59 $\pm$ 0.3	14:0iso	0.34 $\pm$ 0.12	0.35 $\pm$ 0.08	0.37 $\pm$ 0.09
<b><math>\Sigma</math> SFA (%)</b>	<b>78.83 <math>\pm</math> 3.86</b>	<b>73.16 <math>\pm</math> 4</b>	<b>72.7 <math>\pm</math> 6.72</b>	15:0anteiso	0.46 $\pm$ 0.08	0.4 $\pm$ 0.05	0.5 $\pm$ 0.06
<b>Monounsatur.</b>			15:0iso	0.39 $\pm$ 0.06	0.34 $\pm$ 0.04	0.37 $\pm$ 0.04	
16:1 $\omega$ 5	0.08 $\pm$ 0.04	0.08 $\pm$ 0.03	0.07 $\pm$ 0.03	16:0iso	0.21 $\pm$ 0.06	0.21 $\pm$ 0.04	0.23 $\pm$ 0.02
16:1 $\omega$ 7	3.62 $\pm$ 0.73	5.62 $\pm$ 1.1	3.76 $\pm$ 0.75	17:0anteiso	0.64 $\pm$ 0.18	0.99 $\pm$ 0.26	0.23 $\pm$ 0.02
16:1 $\omega$ 9	1.99 $\pm$ 0.49	2.2 $\pm$ 0.46	1.99 $\pm$ 0.57	17:0iso	0.06 $\pm$ 0.01	0.05 $\pm$ 0.02	0.04 $\pm$ 0.01
17:1 $\omega$ 7	0.39 $\pm$ 0.1	0.34 $\pm$ 0.04	0.37 $\pm$ 0.12	18:0iso	0.23 $\pm$ 0.09	0.28 $\pm$ 0.06	0.29 $\pm$ 0.13
18:1 $\omega$ 7	0.65 $\pm$ 0.16	0.73 $\pm$ 0.14	0.8 $\pm$ 0.2	<b><math>\Sigma</math> BrFA (%)</b>	<b>2.34 <math>\pm</math> 0.46</b>	<b>2.62 <math>\pm</math> 0.36</b>	<b>2.03 <math>\pm</math> 0.08</b>
18:1 $\omega$ 9	4.63 $\pm$ 0.91	5.32 $\pm$ 0.71	6.36 $\pm$ 1.9	Total FA (mg.g-1)	2.86 $\pm$ 0.83	4.49 $\pm$ 0.77	3.33 $\pm$ 1.53
22:1 $\omega$ 11	0.36 $\pm$ 0.11	0.39 $\pm$ 0.12	0.42 $\pm$ 0.17	$\Sigma$ $\omega$ 3	4.00 $\pm$ 0.87	5.27 $\pm$ 1.49	6.81 $\pm$ 2.4
<b><math>\Sigma</math> MUFA (%)</b>	<b>11.71 <math>\pm</math> 2.87</b>	<b>14.68 <math>\pm</math> 2.1</b>	<b>13.8 <math>\pm</math> 3.32</b>	$\Sigma$ $\omega$ 6	2.14 $\pm$ 0.14	2.28 $\pm$ 0.11	2.26 $\pm$ 0.14
				$\Sigma$ EFA	2.16 $\pm$ 0.25	2.75 $\pm$ 0.33	4.02 $\pm$ 0.55

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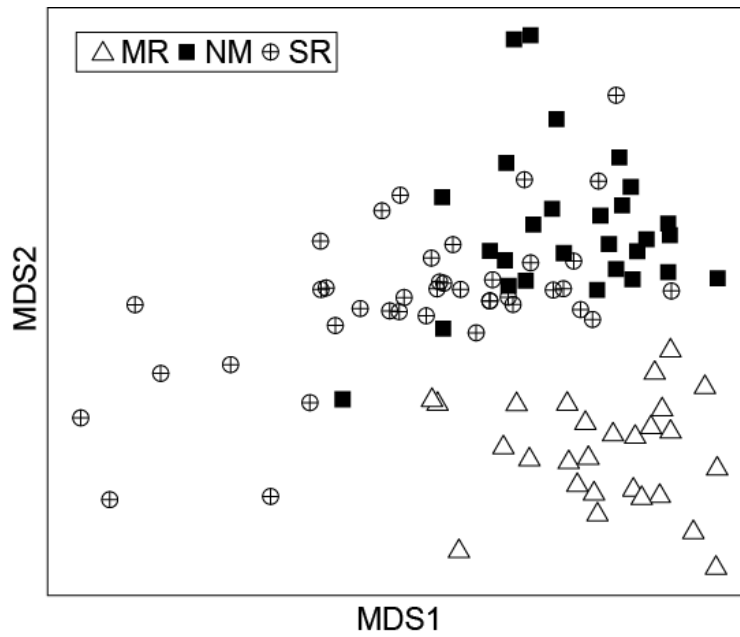


**Figure 1:** Maps of the KH-13-2 sampling survey of the R/V *Hakuho Maru* showing (A) the IKMT stations for collecting leptocephali (St. 32–65) and stations where particulate organic matter (POM) was analyzed (black circles) and where other CTD casts were made (shaded circles). The number of leptocephali caught per station of (B) Muraenidae (C) Nemichthyidae, and (D) Serrivomeridae are represented by the relative sizes of the shaded circles. The general locations of the South Equatorial Current (SEC), South Equatorial Countercurrent (SECC) and South Tropical Countercurrent (STCC) are shown with arrows, and the dotted lines separate the 3 current zones used for analyzing latitudinal differences in SI and FA compositions of leptocephali and POM.

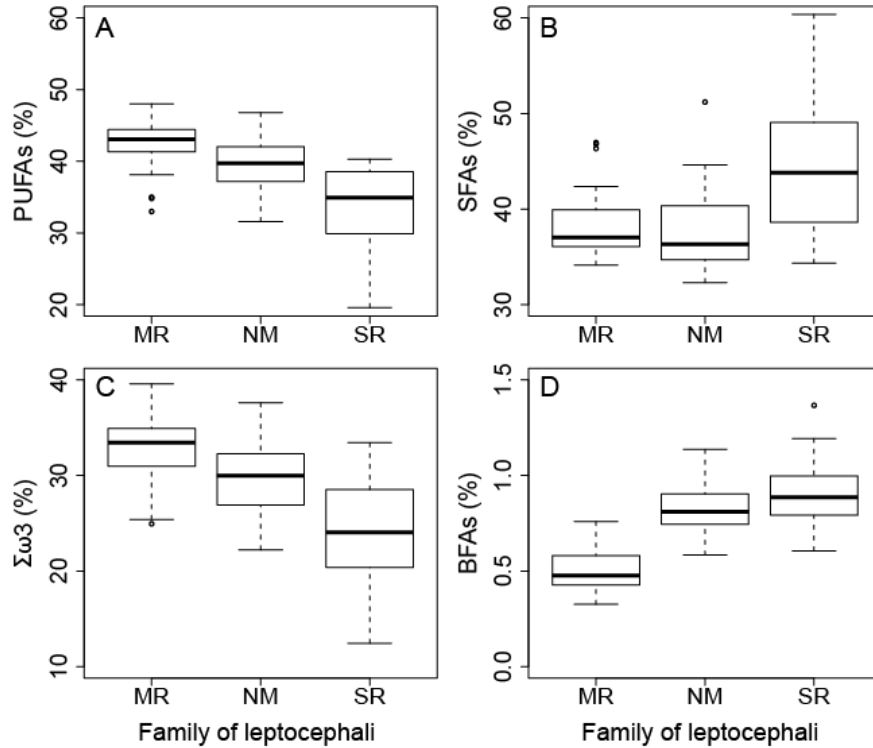


**Figure 2.** Carbon and nitrogen stable isotope values of particulate organic matter (POM) and the leptocephali of the Muraenidae (MR), Serrivomeridae (SR) and Nemichthyidae (NM).

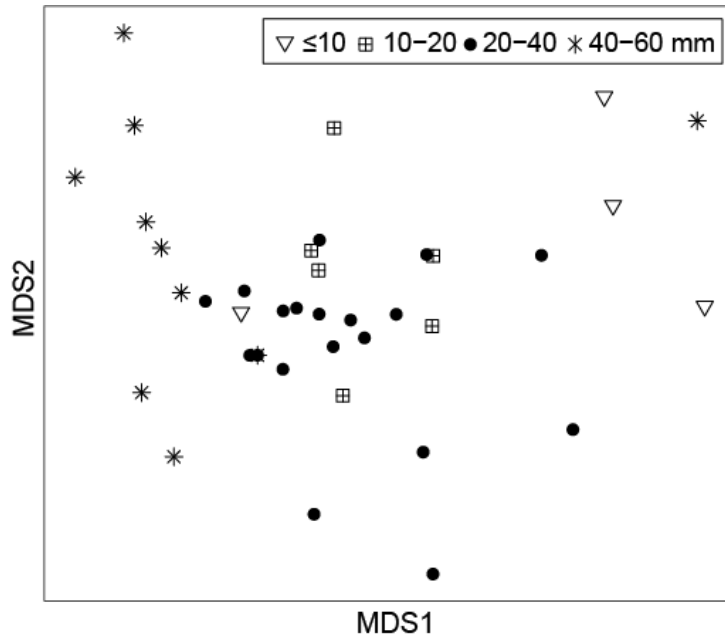




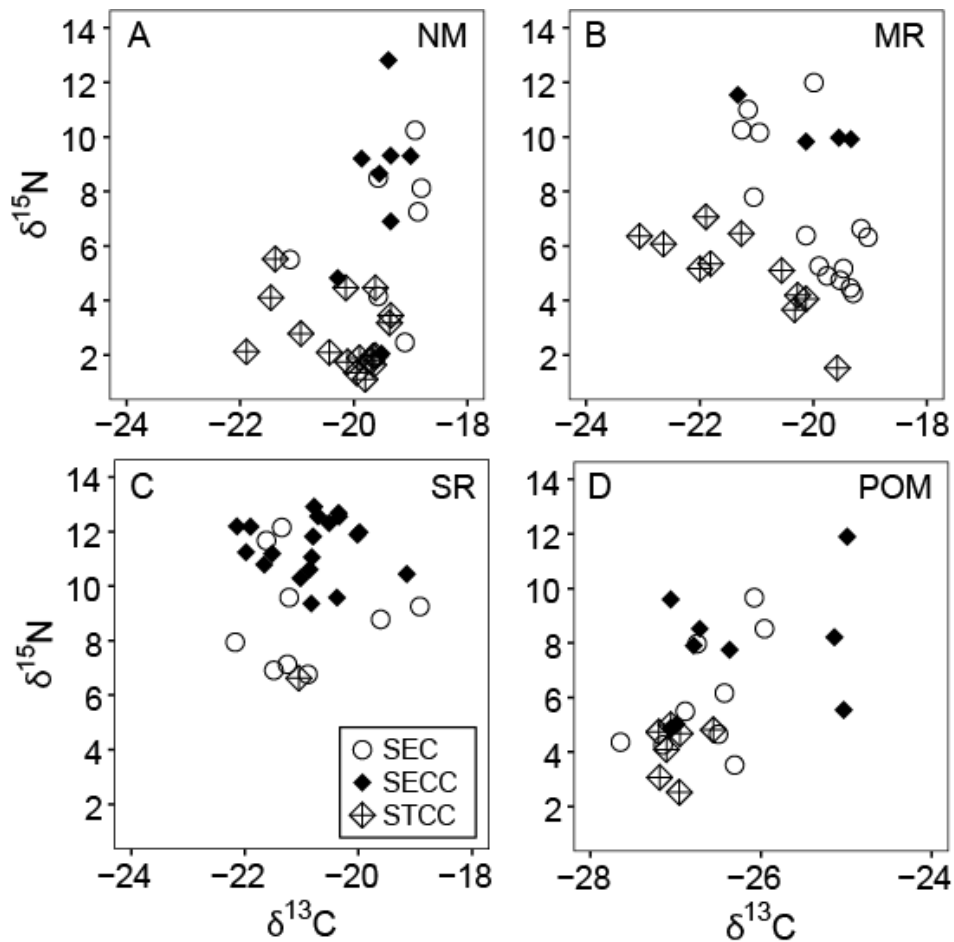
**Figure 3.** Non-metric multi-dimensional scaling (n-MDS) based on Bray-Curtis similarity distance of total fatty acid composition for leptocephali of the Muraenidae (MR), Serrivomeridae (SR) and Nemichthyidae (NM). Stress = 0.12.



**Figure 4.** Fatty acids proportions (median, first and third quartiles) of (a) Polyunsaturated Fatty Acids (PUFAs), (b) Saturated Fatty Acids (SFAs), (c) sum of  $\omega3$  Fatty Acids ( $\Sigma\omega3$ ), (d) Branched-chain Fatty Acides (BrFAs), for the leptocephali of the Muraenidae (MR), Serrivomeridae (SR) and Nemichthyidae (NM).



**Figure 5.** Non-metric MultiDimensional Scaling (n-MDS) based on Bray-Curtis similarity distance of total fatty acid concentration ( $\text{mg g}^{-1}$ ) of Serrivomeridae leptocephali for 4 different size groups (see methods for exact size ranges). Stress = 0.08.



**Figure 6.** Carbon and nitrogen stable isotope values of (A) Nemichthyidae, (B) Muraenidae, (C) Serrivomeridae leptocephali and (D) POM from the 3 current zones of the South Equatorial Countercurrent (SECC), South Equatorial Current (SEC), and South Tropical Countercurrent (STCC).